ERDC/CERL TR-09-28

Construction Engineering Research Laboratory

US Army Corps of Engineers®
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*DoD Corrosion Prevention and Control Program*

# Demonstration of a Mixed Oxide Process for Control of Corrosion and Microbiological Growth in Cooling Towers

Final Report on Project FAR-03 for FY06

Susan A. Drozdz

August 2009

DoD Corrosion Prevention
and Control Program

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Final report

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**Abstract:** The deterioration of heating and cooling systems is considered the top facility corrosion problem by Army facility managers, because heating and cooling services are mission-critical. Cooling towers are susceptible to fouling due to the buildup of algae and other microbiological growth, which can cause corrosion, reduce energy efficiency, and spread disease. A new process has been developed to replace chlorination in cooling water systems by generating an effective biocide on-site using ordinary table salt (sodium chloride) and water in an electrolytic cell. Three cooling towers were treated with this technology at Corpus Christi Army Depot, TX, and a fourth tower was monitored without treatment as a control. The earliest data collected indicate that the pH and conductivity of the cooling tower water did not change significantly after the mixed oxidant generation system was implemented, so no water chemistry adjustments are necessary. Also, the level of microbial activity in the water remains at low pretreatment levels. The data from an in-dependent analysis by the Illinois State Water Survey are not yet available. Data collection and analysis, both at the site and from samples sent to the water survey, will continue through December 2008.

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# Preface

This demonstration was performed for the Office of the Secretary of Defense (OSD) under Department of Defense (DoD) Corrosion Control and Prevention Project FAR 03, “Green Water Treatment Combined with Smart Management System for Control of Corrosion, Scale, and Microbiological Growth in Heating and Cooling Systems”; Military Interdepartmental Purchase Requests MIPR6FCERB1020, dated 23 March 2006 and MIPR6H6AG3CPC1, dated 15 May 2006. The proponent was the U.S. Army Office of the Assistant Chief of Staff for Installation Management (ACSIM), and the stakeholder was the U.S. Army Installation Management Command (IMCOM). The technical monitors were Daniel J. Dunmire (OUSD(AT&L)Corrosion), Paul M. Volkman (IMPW-E), and David N. Purcell (DAIM-FDF).

The work was performed by the Engineering and Materials Branch (CEERD-CF-M), Facilities Division (CF), U.S. Army Engineer Research and Development Center – Construction Engineering Research Laboratory (ERDC-CERL), Champaign, IL. The project managers were Susan A. Drozdz and Vincent F. Hock. Significant portions of this work were performed by Helmut Brugman of SurTech Corporation, Indianapolis, IN.

The project managers gratefully acknowledge the contributions of Dr. Edgar D. Smith of the ERDC-CERL Environmental Processes Branch (CEERD-CN-E). Shawn Smith, Directorate of Public Works, Corpus Christi Army Depot, also is gratefully acknowledged for his support and assistance in this project.

At the time this report was prepared, the Chief of the ERDC-CERL Materials and Structures Branch was Vicki L. Van Blaricum (CEERD-CF-M), the Chief of the Facilities Division was L. Michael Golish, (CEERD-CF), and the Technical Director for Installations was Martin J. Savoie (CEERD-CV-ZT). The Deputy Director of ERDC-CERL was Dr. Kirankumar Topudurti and the Director was Dr. Ilker Adiguzel.

The Commander and Executive Director of the U.S. Army Engineer Research and Development Center was COL Gary E. Johnston and the Director was Dr. James R. Houston.

# Executive Summary

The Army Installation Management Agency (IMA) and the Army Chief of Staff for Installation Management (ACSIM) consider the deterioration of heating and cooling systems to be the top facility corrosion problem due to the critical nature of heating and cooling services, especially in severe environments. Heating and cooling of DoD facilities is critical to mission execution. Cooling tower systems are susceptible to fouling due to the buildup of algae and other microbiological growth. The biofilm can harbor disease-causing bacteria. The development of a biofilm can increase corrosion rates, and decrease the energy efficiency of heat transfer surfaces.

A new disinfectant process has been developed to replace chlorination in cooling water systems. The mixed oxidants process generates a disinfection solution from ordinary table salt (sodium chloride) and water in an electrolytic cell to generate the disinfectant solution on-site, replacing chlorine gas and bulk bleach disinfection systems. No hazardous materials are transported to or stored onsite, reducing environmental risks, and safety hazards, and the problem of solution degradation during storage.

Three cooling towers were treated with this process at Corpus Christi Army Depot, and a fourth tower was monitored without treatment as a control. CCAD was selected as a demonstration site because it had different types of cooling towers running in a corrosive environment with a high cooling demand. Data collected at the site in the early weeks of performance monitoring indicate that the pH and conductivity of the cooling tower water do not change significantly when the mixed oxidant generation system is implemented. The data from an independent analysis by the Illinois State Water Survey are not yet available. Data collection and analysis, both at the site and from samples sent to the water survey will continue for a full 9 months after startup of the system.

A lesson learned during the first application was that the use of finely ground table salt can clog system filters. The clogging was prevented by placing a bed of quartz rocks in the bottom of the brine tank, where the salt precipitate can settle and dissolve into solution over time. The subsequent applications are using a granulated form of salt to avoid clogging and the expense of using a quartz settling bed.

# Unit Conversion Factors

| Multiply | By | To Obtain |
|---|---|---|
| degrees Fahrenheit | (F-32)/1.8 | degrees Celsius |
| feet | 0.3048 | meters |
| gallons (U.S. liquid) | 3.785412 E-03 | cubic meters |
| inches | 0.0254 | meters |
| mils | 0.0254 | millimeters |
| square feet | 0.09290304 | square meters |

# 1 Introduction

## 1.1 Problem statement

The U.S. Army Installation Management Command (IMCOM) and the Army Chief of Staff for Installation Management (ACSIM) consider the deterioration of heating and cooling systems to be the top facility corrosion problem due to the critical requirement for space conditioning, especially in severe environments. Heating and cooling services in DoD facilities are critical to mission execution. Personnel must be provided with a habitable training, working, and living environment, and mission-critical electronic equipment such as high-performance computers and flight simulators must be continuously cooled to avoid failure.

Cooling tower systems are susceptible to fouling due to the buildup of algae and other microbiological growth. The development of a biofilm can increase corrosion rates while decreasing the energy efficiency of heat-transfer surfaces. Such biofilm also can host pathogenic bacteria such as *Legionella pneumophila*, the cause of Legionnaire's disease. The standard technology for the suppression of biofilm growth is chlorination of the carrier fluid using chlorine gas or bulk bleach disinfecting systems. These chlorination systems can increase the incidence of corrosion inside the system even as they suppress biofilm development.

A new cooling system disinfectant technology known as the *mixed oxidants process* has been developed to replace conventional chlorination methods. This process eliminates biofouling and scaling, and is claimed to be less corrosive than conventional chlorination. One such disinfection technology is distributed under the trade name MIOX, by the MIOX Corporation, Albuquerque, NM. The company claims that its system removes existing biofilm, and greatly reduces both micro-biologically-induced corrosion and corrosion due to sulfate-reducing bacteria. The equipment is available in a range of sizes, from battery-powered personal drinking water purifiers through large-scale devices for disinfecting cooling tower or swimming pool water. The technology was originally developed in the 1980s by the Los Alamos Technical Associates (LATA) in response to the Army's solicitation for a simple, portable alternative water purification system.

The mixed oxidant technology uses ordinary table salt (sodium chloride) and water in an electrolytic cell to generate the biocide onsite. The biocide is a solution containing chlorine and chlorine compounds generated in the electrolytic cell and monitored as free chlorine as it is dosed into the cooling tower system. There are several advantages to this process over the use of bulk chemicals:

- No hazardous materials such as chlorine gas or sodium hypochlorite need to be transported to or stored at the facility.
- Regulatory requirements for risk management plans, hazardous materials training, etc., are eliminated.
- On-demand production of the biocide eliminates the problem of solution degradation as it sits in storage.
- Corrosivity is reduced because the oxidant does not offgas at normal system operating temperatures.
- The resulting free chlorine concentration of <1% is classified as nonhazardous.

## 1.2 Objective

The objectives of this work were to:

- Demonstrate a state-of-the-art treatment system for controlling microbiological growth and associated corrosion in cooling towers at an Army site with a high cooling demand and a corrosive environment;
- Monitor the performance of the system on three cooling towers for a period of 9 – 12 months and compare these results to monitoring done without treatment on a fourth cooling tower at the site;
- Develop implementation guidance for the use of the technology at DoD installations.

## 1.3 Approach

The Corpus Christi Army Depot was selected as the demonstration site because it uses cooling tower of different types and sizes that operate in a corrosive environment. The site also had sufficient space available in the mechanical rooms for placement of the control system and solution tanks.

Additional details about how this demonstration was executed are provided in Appendix A, “Project Management Plan for CPC Project FAR-03”; and Appendix B, “Contractor Documentation.”

# 2 Technical Investigation

## 2.1 Project overview

A schematic drawing of the MIOX system is shown in Figure 1. For the Corpus Christie cooling system applications, smart monitoring and control systems were installed to continuously monitor and dose the cooling water. Specifically, the automated control system verifies uniform and effective treatment for cooling towers and consistent protection against corrosion, scale, and microbiological growth. The nonhazardous MIOX process and the smart control system provide a longer, energy efficient service life, lower life-cycle operating costs, improved safety, and reduced risk of environmental contamination.

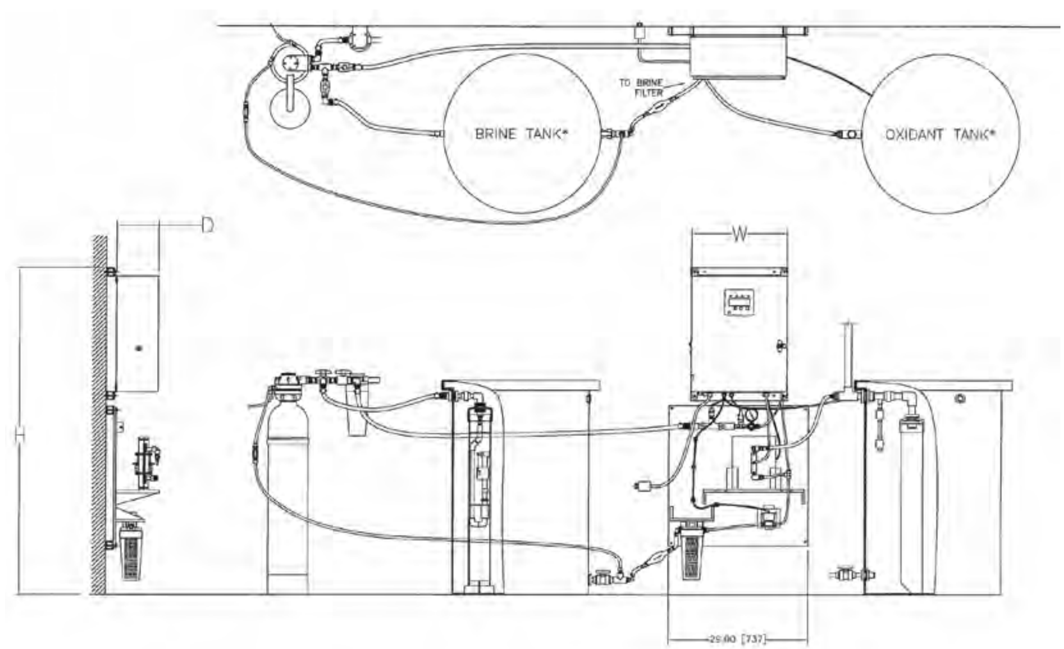


Figure 1. Schematic of the MIOX system. Source: MIOX Corp.

## 2.2 Installation of the technology

On 10 – 11 April 2008, SurTech Corporation initiated the MIOX program at Corpus Christi Army Depot. MIOX equipment was subsequently installed at the locations shown in Table 1. The company's installation manual for the MIOX is included as an attachment to Appendix B.

Table 1. Selected cooling tower systems.

| MIOX Model | Site | Tower Type | Chiller Type | Chiller Size |
|---|---|---|---|---|
| SAL-30 | Mechanical Room 8 | Marley Class NC galvanized steel | York Screw Chiller | 180 tons |
| SAL-40 | Mechanical Room 9 | Evapco | Trane Centravac Rotary Chiller | 130 tons |
| SAL-40 | Mechanical Room 95 | Evapco | Carrier Screw Chiller | 96 Tons |

Two areas that caused problems during installation were (1) securing permission to drill a 1 in. vent to exhaust the hydrogen gas emission through the ceiling at each location and (2) arranging a dedicated electrical supply line with its own circuit breaker. The actual installation of the technology by SurTech's mechanical subcontractor proceeded without problem.

The first unit brought online was in Mechanical Room (MR) 8. Figure 2 shows the MIOX control panel and the electrolytic cell that generates biocide using electric current and a saline solution. Figure 3 shows, from left to right, the oxidant feed tank, the water softeners, and the brine tank.


Figure 2. MIOX control panel (top) and electrolytic cell (bottom).


Figure 3. In-line components of the MIOX biocide-generating system.

One part of the final startup phase at MR-8 has caused the contractor to reconfigure the startup at the other two locations. The MIOX process requires a very pure form of sodium chloride salt. For this purpose the contractor originally procured 50 lb bags of Tru-Flow Evaporated Food Grade table salt. Because the fine salt crystals will plug a filter down stream in the MIOX unit, it was necessary to put several bags of two different grades of quartz rocks in the bottom of the brine tank to provide a settling bed for the salt. After the work was done on MR-8, the installers opted to use a pellet form of salt at the other locations. Using pelletized salt makes it unnecessary to provide a quartz settling bed, avoiding the expenditure of $150 – 200 per location for the rocks.

## 2.3 Technology operation

All MIOX SAL units are preprogrammed so that once power and water are supplied to the equipment, the control panel automatically generates the desired mixed-oxidants.

It was necessary to experiment with the brine and soft water flows to maximize the concentration of the oxidant (biocide) that was made. An oxidant

tank is included inline to store the biocide until it is fed to the recirculating cooling tower using a chemical feed pump. The biocide pump used with the previous microbiological control chemical was adapted to feed the mixed oxidant to the system.

An adjustment period of several weeks is required before the MIOX systems reach their intended steady state. The mixed-oxidant solution in the oxidant tank started at a concentration of 1,500 mg/l, with the target concentration being 3,400 – 4,000 mg/l. Adjustment of the biocide concentration to the proper levels for controlling microbial growth is achieved by changing the flow rate of the chemical feed pump.

The established corrosion and scale control programs required no change after implementation of the MIOX system. A commercial corrosion inhibitor formulated with phosphonates and sodium tolutriazole is used, and sulfuric acid controlled calcium scale buildup.

## 2.4 Performance monitoring

Two instantaneous corrosion probes were installed in a corrosion coupon bypass assembly along with two permanent metal coupons. The instantaneous probes have CDA[1] 110 copper electrodes and C1010 steel electrodes. The same metals are used for the permanent coupons. During the demonstration period, instantaneous corrosion readings are obtained every 2 weeks by the service representatives, and the coupons are changed every 30 days. These coupons will be sent to the Illinois State Water Survey for analysis. Before initiation of the MIOX treatment, samples of the makeup water and cooling tower water were taken for analysis by the survey.

The MIOX system is monitored and operated by a smart controller programmed to maintain a constant concentration of biocide in the oxidant solution tank. The controller maintains a 24-hour supply in the tank at the proper concentration. The system can be set up to activate a remote alarm when it requires additional salt or other service, and it can transmit data for remote display.

[1] CDA: Copper Development Association.

# 3 Discussion

## 3.1 Metrics

Three open circulating cooling towers are treated with the OSG system, and a fourth tower is set up as a control for collecting baseline data.

Every 2 weeks the onsite mechanical contractor was to visit the site and perform the following tests on the three treated towers and the control:

- Tower water

1. Calcium Hardness – record
2. Total Alkalinity – record
3. pH - 7.0 – 9.0
4. Specific Conductivity – 3,500 micromhos maximum
5. Total Available Free Chlorine – 0.5-1.0 mg/l
6. Total Bacteria – 1,000 CFU (colony-forming units)
7. Inhibitor Concentration
8. Corater Corrosion Readings for Iron (3.0mpy max.) and Copper (0.10 mpy max.)
9. Optional Tests – Iron, Copper

- Makeup water

10. Calcium Hardness – Water softened by MIOX to 0-3 mg/l
11. Total Alkalinity – record, not significant
12. pH – 7.0 – 9.0
13. Specific Conductivity – record
14. Total Available Free Chlorine – record
15. Total Bacteria – record
16. Optional Tests – iron, copper

Each tower was outfitted with a bypass loop for installing copper and steel corrosion coupons, which were scheduled to be removed and replaced with new coupons once per month. The coupons were supplied by and returned to the Illinois State Water Survey for analysis. Samples of makeup water and water from each of the four towers also were collected once a month and sent to the water survey for independent analysis.

## 3.2 Results

Data collected at the site during the early weeks of performance monitoring indicate that the pH and conductivity of the cooling tower water do not change significantly when the mixed oxidant generation system is implemented. Therefore, the water chemistry does not need to be adjusted to compensate for the effects of system. The microbiological counts were considered excellent, at below 1,000 CFU/ml before implementation, and they remained below 1,000 CFU/ml when operating with the mixed oxide system biocide. The interim data are shown in Table 2 and Figure 4.

Table 2. Initial MIOX comparative data from Mechanical Room 8.

| System | Date | Conductivity, uS/cm | TSC, Inhibitor Tracer | Microbiological, CFU/ml | pH |
|---|---|---|---|---|---|
| Pre MIOX | 3/5/2008 | 2811 | 2.6 | <10+3 | 8.2 |
| | 3/12/2008 | 3145 | 13 | <10+3 | 8.3 |
| | 3/20/2008 | 2600 | 6 | <10+3 | 8.5 |
| | 3/27/2008 | 3494 | 7.5 | <10+3 | 8.4 |
| | 4/9/2008 | 3455 | 4.4 | <10+3 | 8.7 |
| With MIOX | 4/24/2008 | 3463 | 5.7 | <10+3 | 8.7 |
| | 4/30/2008 | 3523 | 7.5 | <10+3 | 8.6 |
| | 5/7/2008 | 3335 | 7.5 | <10+3 | 8.7 |
| | 5/14/2008 | 3361 | 5.8 | <10+3 | 8.5 |

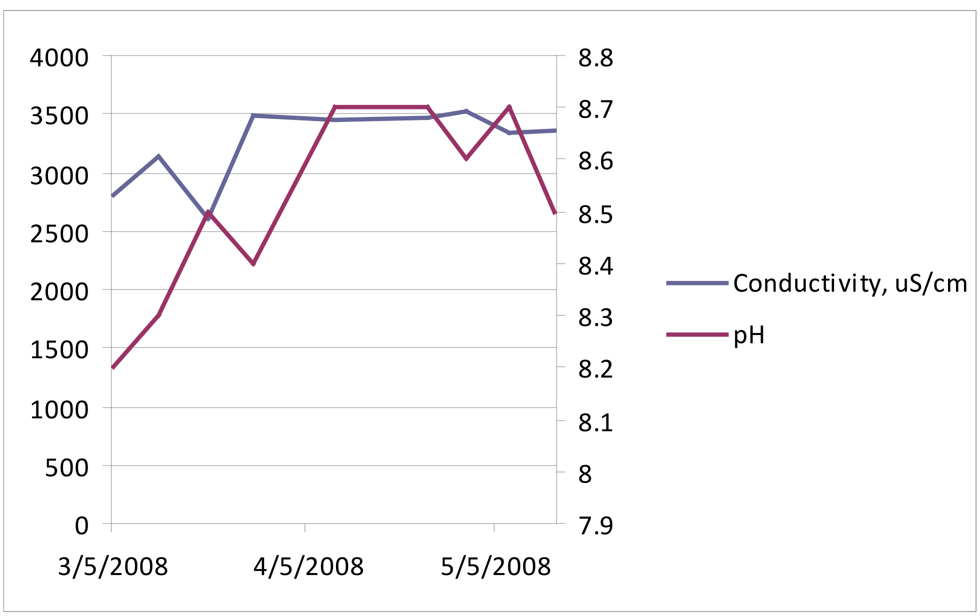


Figure 4. Water chemistry trend lines for conductivity and pH, March – May 2008.

A formal analysis will be performed at the end of the 9 month evaluation period (approximately December 2008).

## 3.3 Lessons learned

The type of salt selected for developing the brine may negatively impact system performance. If food-grade table salt is used, it must be mixed in a brine tank containing a settling bed of quartz rocks. The quartz remains chemically inert in the carrier fluid, but the gravel allows suspended salt crystals to settle to the bottom of the tank, where the salt can dissolve quiescently at the intended rate, undisturbed by water turbulence. Without the settling bed, salt sediment may flow through the system and clog downstream filters. In order to avoid the need for a quartz settling bed in the brine tank, the use of pelletized forms of salt is recommended.

# 4 Economic Summary

Conventional treatment of cooling towers with chlorine in the form of chlorine gas or sodium hypochlorite solution involves:

- purchasing the disinfectant
- transporting it to the site as a hazardous material
- storing the hazardous material onsite.

The new technology transports the raw materials in a much more efficient form. The volume of hypochlorite solution is nearly five times larger than the volume of salt required to generate an equivalent amount of hypochlorite on site. Therefore, it is reasonable to estimate that the shipping requirement and the associated carbon footprint for the required salt is one-fifth that of transporting sodium hypochlorite in bulk. There are direct savings in the purchase, with shipping costs, of the salt; and indirect savings in the environmental impact of the reduced shipping requirement. Also, the cost of raw materials for both hypochlorite and chlorine gas have been climbing drastically over the past several years, while the cost of salt has remained relatively constant.

## 4.1 Costs and assumptions

Demonstration project costs are shown below:

| *Funding Source* | *OSD* | *Matching* |
|---|---|---|
| Labor | 80 | 145 |
| Materials/Contracting | 225 | 292 |
| Navy / Air Force Support | 20 | 20 |
| Travel | 10 | 10 |
| Report | 15 | 0 |
| Total | 350 | 467 |

A typical installation maintains as many as 35 cooling towers. An operating budget for this number of towers has been estimated at $690K per year, based annual operating costs of $290K and repair/replacement costs of $400K per year (two new towers per year).

The operating costs of the new system are estimated at $195 per year, and are associated with an indirect cost avoided of $125K per year (costs of relocating personnel and equipment to alternate space during a cooling tower failure).

## 4.2 Projected return on investment (ROI)

1. Projected Useful Life Savings (ULS) is equal to the “Net Present Value (NPV) of Benefits and Savings” calculated from the Spreadsheet shown in Appendix A that is based on Appendix B of OMB Circular A94.

ULS= $7,693K (from OMB Spreadsheet.

2. Project Cost (PC) is shown as “Investment Required” in OMB Spreadsheet in Appendix A; PC= $817K.

3. Potential ROI – Computation

$$\text{Potential ROI} = \frac{\text{ULS}}{\text{PC}} = \frac{\$\,7{,}693\text{K}}{\$\,817\text{K}} = 9.42$$

The calculated ROI for this project, which is based on current best practices, projected maintenance, and rehab costs, has the potential to increase over the multiple-year implementation. An expected reduction in cooling system downtime will result in higher indirect savings.

| | | | |
|---|---|---|---|
| **Investment Required** | | | **817,000** |
| **Return on Investment Ratio** | **9.42** | **Percent** | **942%** |
| **Net Present Value of Costs and Benefits/Savings** | **2,419,697** | **10,113,091** | **7,693,394** |

| B<br>Baseline Costs | C<br>Baseline Benefits/ Savings | D<br>New System Costs | E<br>New System Benefits/ Savings | F<br>Present Value of Costs | G<br>Present Value of Savings | H<br>Total Present Value |
|---|---|---|---|---|---|---|
| 690,000 | | 195,000 | 125,000 | 182,247 | 761,699 | 579,452 |
| 690,000 | | 195,000 | 125,000 | 170,313 | 711,821 | 541,508 |
| 690,000 | | 195,000 | 125,000 | 159,179 | 665,285 | 506,106 |
| 690,000 | | 195,000 | 125,000 | 148,766 | 621,764 | 472,998 |
| 690,000 | | 195,000 | 125,000 | 139,035 | 581,095 | 442,060 |
| 690,000 | | 195,000 | 125,000 | 129,929 | 543,035 | 413,106 |
| 690,000 | | 195,000 | 125,000 | 121,427 | 507,501 | 386,074 |
| 690,000 | | 195,000 | 125,000 | 113,490 | 474,330 | 360,840 |
| 690,000 | | 195,000 | 125,000 | 106,061 | 443,279 | 337,218 |
| 690,000 | | 195,000 | 125,000 | 99,119 | 414,265 | 315,146 |
| 690,000 | | 195,000 | 125,000 | 92,645 | 387,207 | 294,562 |
| 690,000 | | 195,000 | 125,000 | 86,580 | 361,860 | 275,280 |
| 690,000 | | 195,000 | 125,000 | 80,925 | 338,225 | 257,300 |
| 690,000 | | 195,000 | 125,000 | 75,621 | 316,057 | 240,436 |
| 690,000 | | 195,000 | 125,000 | 70,668 | 295,356 | 224,688 |
| 690,000 | | 195,000 | 125,000 | 66,047 | 276,041 | 209,994 |
| 690,000 | | 195,000 | 125,000 | 61,737 | 258,029 | 196,292 |
| 690,000 | | 195,000 | 125,000 | 57,701 | 241,159 | 183,458 |
| 690,000 | | 195,000 | 125,000 | 53,918 | 225,348 | 171,430 |
| 690,000 | | 195,000 | 125,000 | 50,388 | 210,596 | 160,208 |
| 690,000 | | 195,000 | 125,000 | 47,093 | 196,823 | 149,730 |
| 690,000 | | 195,000 | 125,000 | 44,012 | 183,946 | 139,934 |
| 690,000 | | 195,000 | 125,000 | 41,126 | 171,884 | 130,758 |
| 690,000 | | 195,000 | 125,000 | 38,435 | 160,637 | 122,202 |
| 690,000 | | 195,000 | 125,000 | 35,919 | 150,123 | 114,204 |
| 690,000 | | 195,000 | 125,000 | 33,579 | 140,343 | 106,764 |
| 690,000 | | 195,000 | 125,000 | 31,376 | 131,134 | 99,758 |
| 690,000 | | 195,000 | 125,000 | 29,328 | 122,576 | 93,248 |
| 690,000 | | 195,000 | 125,000 | 27,417 | 114,589 | 87,172 |
| 690,000 | | 195,000 | 125,000 | 25,623 | 107,091 | 81,468 |

# 5 Conclusions and Recommendations

## 5.1 Conclusions

To date, the cooling tower disinfection system demonstrated in this project has been shown to provide good control of the microbiological growth in the systems, and does not produce corrosive chlorine byproducts. The use of this disinfection system eliminates the need to transport and store hazardous chlorine compounds onsite. This technology has the potential to deliver these benefits to virtually all open recirculating cooling towers in use at DoD facilities.

## 5.2 Recommendations

### 5.2.1 Applicability

In theory, the mixed oxidant biocide generation process is applicable to most open recirculating cooling towers. These disinfection systems are available in sizes that generate 2.5 – 1,000 lb of free available chlorine per day. The units demonstrated in this project generate 2.5 – 4 lb per day for each of three small cooling towers, ranging from 96 – 180 tons. When the full data collection period is complete and the data have been analyzed, ERDC-CERL will develop guidance for effective application of the technology to open recirculating cooling towers at DoD installations.

### 5.2.2 Implementation

The following DoD criteria documents cover water treatment in cooling towers:

1. UFC 3-410-02N "Heating, Ventilating, Air Conditioning, and Dehumidifying Systems", 8 Jun 2005
2. UFGS 23 64 26 "Chilled, Chilled-Hot, and Condenser Water Piping Systems"

It is recommended that both documents be updated to include the mixed oxidant technology for control of microbiological growth. Based on the preliminary results of this demonstration, the following change is recommended for UFC 3-410-02N, section 7.2.1.3, "Water Treatment":

> 7.2.1.3 Water Treatment. Selection of a water treatment system is based on analysis of makeup water and its anticipated contribution to internal corrosion and scale formation in distribution piping and heat transfer equipment, both of which will affect system efficiency and capacity. Obtain services of a water treatment specialist to perform a water analysis, if not available at the site, and to make specific recommendations on type and quantity of chemicals used. Coordinate the decision on type of chemicals specified with the local environmental program manager to ensure chemicals can be properly handled and disposed of and that pollution control regulations are properly addressed. Consider the use a system which generates chlorinated biocide on-site from sodium chloride (table salt). This type of system will eliminate the need for purchasing and storing hazardous chlorine or hypochlorite solution at the site, and the problem of degradation of these solutions in storage.

The following change is recommended for UFGS 23 64 26, section 2.11.6, "Condenser Water," to be added as a note to the designer immediately before the last sentence:

> Onsite generation of a mixed-oxide treatment for the control of microbiological growth in open recirculating cooling towers shall be considered as a replacement for conventional chlorination methods where feasible in order to reduce fouling of the tower and basin, which is associated with both corrosion and a reduction in energy efficiency.

# Appendix A: Project Management Plan for CPC Project FAR-03

TRI-SERVICE PROGRAM
ARMY FACILITIES
CORROSION PREVENTION AND CONTROL PROJECT PLAN
Green Water Treatment Combined with Smart Management System
for Control of Corrosion, Scale and Biological Growth
in Heating and Cooling Systems

TRI SERVICE PROGRAM
ARMY FACILITIES

CORROSION PREVENTION AND CONTROL PROJECT PLAN

Green Water Treatment Combined with Smart Management System for Control of Corrosion, Scale and Biological Growth in Heating and Cooling Systems (RDTE)

15 June 2005

Submitted By:

Vincent F. Hock

U. S. Army Engineer Research & Development Center (ERDC)
Construction Engineering Research Laboratory (CERL)
Comm: 217-373-6753

(Project Number to be *assigned by OSD when approved*)

TRI-SERVICE PROGRAM
ARMY FACILITIES
CORROSION PREVENTION AND CONTROL PROJECT PLAN
Green Water Treatment Combined with Smart Management System for Control of Corrosion, Scale and Biological Growth in Heating and Cooling Systems

## 1. STATEMENT OF NEED

**PROBLEM STATEMENT**: The Army Installation Management Agency (IMA) and the Army Chief of Staff for Installation Management (ACSIM) consider the deterioration of heating and cooling systems to be the #1 priority facility corrosion problem due to the critical nature of heating and cooling services especially in severe environments. Providing heating and cooling to DoD facilities is critical to mission execution. Personnel must be provided with a reasonable training, working, and living environment, and mission critical electronic hardware like the flight simulators at Fort Rucker must be kept at proper operating temperatures. Maintaining effective heating and cooling is critical at every installation.

Fort Rucker, for example, has experienced critical problems with corrosion of boilers and cooling towers. The expected service life of this equipment is 30 years. At Fort Rucker, cooling towers are replaced after 7 to 12 years. These problems are common to most Army facilities and Navy and Air Force installations as well. This is a tri-service priority problem.

Fort Wainwright has experienced significant corrosion related failures and environmental problems associated with closed loop heating systems. These systems require the use of an anti-freeze as well as corrosion inhibitor. Failure of the heating system can severely impact the training and mission as well as other mission critical operations.

**IMPACT STATEMENT**:

Winter boiler failure can displace residents from their homes and workplaces. Hot water boilers provide water for cleaning and sanitation, food preparation, and shower facilities. This demand is year round. Cooling interruption can also impact training and other critical missions and capabilities, which can have an adverse effect on the U.S. Army's and other armed forces such as the Navy and Marine Corps (who also utilize these facilities for certain mission training and simulation profiles). Their ability to successfully execute certain missions could be vital to the national defense.

Safety and environmental impact are also major concerns for outdated systems with poor chemical control of toxic treatment chemicals. The demonstration of new, emerging technologies environmentally friendly water treatment formulations and the development of up-to-date selection guidance are necessary to help DoD installations be "smart buyers" of water treatment for new and existing heating and cooling systems.

DoD heating and cooling plants fail prematurely due to corrosion, scaling, and biological growth in boilers, cooling towers, and distribution systems. These problems are especially critical in severe environments, where there are high demands on heating and cooling systems. Prior to failure, the equipment is impacted by interruption of heating and cooling services, reduced heating and cooling efficiency and increased cost

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due to reduced flow though pipes, reduced heat transfer in boilers and condensers, and component failures. Preventative treatments for these problems are based upon chemical compounds that are most often toxic and environmentally persistent.

Manufacturers continue to introduce new chemicals and treatment programs onto the market, and old products have been discontinued. Many manufacturers claim that the new chemical and treatments are more environmentally friendly and safer for the plant workers and the users. Current and consistent guidelines for chemical treatment are not available, and current guidelines are not always implemented as recommended. Poor treatment has resulted in reduced system reliability and efficiency, increased maintenance needs and shortened service life of components and systems. Indirect costs for heating and cooling loss can be great when facilities and housing areas must be closed or work days shortened.

If this project is not funded, boilers and cooling towers will continue to deteriorate at an accelerated rate and fail prematurely. Premature failure of boiler and cooling tower components will continue to impact training and mission execution, as well as readiness.

## 2. PROPOSED SOLUTION

**TECHNICAL DESCRIPTION**: A new chemical formulations for heating and cooling systems have recently been introduced, most notably in the areas of: environmentally friendly, or "green" chemical formulations such as the MIOX mixed oxidant process and glycol alternatives for treating boiler and cooling systems combined with smart monitoring and control systems that use just enough chemicals, when needed to maintain optimal treatment levels for corrosion, scale, and microbiological growth. In this context, "environmentally friendly" formulations are those that have low toxicity, are biodegradable, are safe and low cost to dispose of when spent, and whose production has minimal negative environmental impact. Two new chemical treatment approaches combined with smart monitoring and control system will be implemented.

**MIOX Mixed Oxidant Process**: A new disinfectant process has been developed to replace chlorination in cooling water systems. The MIOX process, manufactured by the MIOX Corporation in Albuquerque, NM, replaces chlorine gas and bulk bleach disinfecting systems. The process eliminates biofouling and reduces corrosion and scaling. Existing biofilm is removed, and micro-biologically-induced corrosion and corrosion due to sulfate-reducing bacteria are greatly reduced.

The mixed oxidant technology processes salt and water in an electrolytic cell to generate the disinfectant solution on-site. There are several advantages to this process over the use of bulk chemicals:

- No hazardous chemicals are used, stored, or produced
- Regulatory requirements for risk management plans, hazmat training, etc. are eliminated
- No degradation of disinfectant solution as it sits in storage

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- Reduced corrosion, as the oxidant does not off-gas at normal operating temperatures
- Free chlorine concentration of <1% is classified as non-hazardous

This technology was developed by the Los Alamos Technical Associates (LATA) in the 1980's in response to the Army's solicitation for a simple, portable alternative water purification system. In addition to cooling towers, the technology can be scaled for use in swimming pools, wastewater treatment, and hand-held units for field disinfection of potable water.

This technology will be implemented at 3 cooling towers at Fort Rucker.

For both the heating and cooling systems applications quality corrosivity and smart monitoring and control system applications will be installed to continuously monitor the water into the system exactly when needed and in the amount required.

The automated system reduces the manual analysis and chemical handling currently required with most systems, and results in the uniform treatment for cooling towers, consistent protection against corrosion, scale, and microbiological growth, and a cleaner, safer, and more environmentally friendly treatment approach.

Taken together, the non-hazardous MIOX mixed oxidant process and the smart control systems result in a longer, energy efficient service life, lower life cycle cost operating costs, increased safety and reduced risk of environmental contamination.

The smart monitoring and control system will be implemented on the cooling systems at Fort Rucker.

**Glycol Alternative:** A low toxicity, more efficient coolant has been developed to replace ethylene and propylene glycols in closed loop chillers and heat transfer applications in extreme environments. CP Therm, formerly known as Enviro-Kool, is marketed by CPI Engineering Services, Midland, Michigan. This new, high performance fluid has operating temperatures ranging from -70°F to 300°F. Its high thermal conductivity improves heat transfer capacity compared to glycol/water systems. Heat transfer efficiency can be increased by 20 = 30% compared to glycol/water mixtures. The product's low viscosity at low temperature (Figure 1.) reduces the energy requirements for pumping, allowing the use of smaller pumps and resulting in cost savings.

The product is non-toxic, non-flammable and biodegradable. It has a very low biochemical oxygen demand (BOD), which reduces the risk of fish kills in case of accidental discharge. CP Therm is not an air pollutant like glycols, and it is safe for skin contact. It is delivered ready to use as a direct glycol replacement without any equipment modifications. It is formulated with a specially designed corrosion inhibitor.

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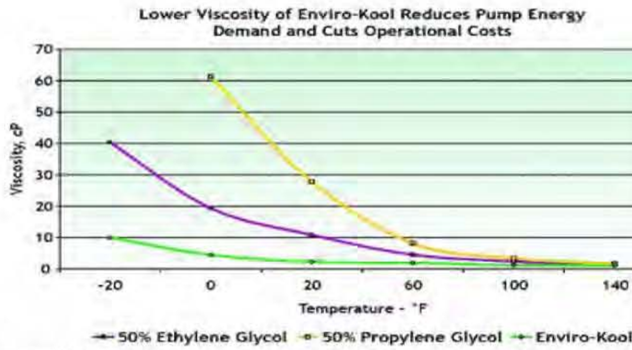


**Figure 1. Viscosity of Glycols and the Enviro-Kool Replacement**

At Fort Wainwright, the boilers at the Central Heat and Power Plant are coal fired and produce steam at 400 psi to feed the turbines to produce electricity. The boiler water is treated with a recently installed filtration and reverse osmosis system to remove all contaminants. Steam is removed from the turbines at 100 psi and distributed throughout the post for comfort and water heating. Within each building, the steam is used through exchangers to heat glycol/water mixes which are pumped through the buildings for heating. The primary purpose of the glycol mixture is its freeze protection, and the secondary purpose is corrosion protection.

The CP Therm product will be used at the building heating level to replace the glycol/water mix in 8 to 10 building heating systems at Fort Wainwright, depending on the size and site factors. It will also be implemented in 5 to 7 closed loop chiller systems at the U.S. Military Academy at West Point, depending on size and configuration in a less severe environment then Fort Wainwright.

Implementation of these projects is projected to show a return on investment ratio of 10.34, and realize savings of $15.5 M.

**TECHNOLOGY MATURITY**: The formulations for non-hazardous water treatments and smart control systems for heating and cooling are mature. The smart control system has been developed and field tested.

**RISK ANALYSIS**: This is a low risk project, as the treatment formulations and smart control system are commercially available from multiple manufacturers. Small-scale, preliminary field trials of the non-hazardous formulations were successfully completed. Also, the sites for implementation of this project have been coordinated with Mr. Tommy Baldwin and Mr. Ray Schroeder at Fort Rucker, Mr. Steve Driver at West Point, and Mr. Pat Driscoll at Fort Wainwright.

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**EXPECTED DELIVERABLES AND RESULTS/OUTCOMES**: Across the three implementation sites, the non-hazardous inhibitor formulations and smart monitoring and control systems will be implemented in an estimated 10 heating and 10 cooling systems. Additional heating and cooling plants at installations in the region will be inspected to assess the efficacy of installing the smart corrosion control system at these sites. Specifications for non-hazardous boiler and cooling tower treatments and the smart control system will be developed, and the systems will be installed. Training on system operation and maintenance will be provided to the installations. The operational efficiency of the heating and cooling systems will be determined, and downtime due to corrosion failure, safety and environmental impact will be assessed.

Unified Facilities Guide Specifications (UFGS), Engineering Instructions (EI), Technical Instructions (TI), and Technical Manuals (TM), including updates, along with a final report describing the details of the project, will be developed and posted on the OSD Corrosion Exchange website under "Spec & Standards." In addition, the draft documents will be posted on the ERDC-CERL Corrosion Prevention and Control Program (CPCP) website.

PROGRAM MANAGEMENT: The Project Manager will be: Vincent Hock (ERDC-CERL Senior Researcher and Metallurgist). The Associate Project Managers will be: Ms. Susan Drozdz (ERDC-CERL) and Mr. Noel Potts (ERDC-CERL). The stakeholders will be Mr. Alan Carrol (IMA-PARO), Mr. Steve Jackson (IMA-SERO), Mr. Tom Tehada (USN) and Ms. Nancy Coleal (USAF).
The customers are: Mr. Tommy Baldwin at Fort Rucker, Mr. Pat Driscoll at Fort Wainwright, and Mr. Steve Driver at West Point.

Army ACSIM will provide matching funds in the amount of $1M on this project. (See attached Memorandum for ACSIM Director for Facilities and Housing in Appendix 2.) Coordination with the Army Corrosion Programs Office is with Mr. Hilton Mills (AMC).

This is a TriService Project. Funds have been requested for Air Force and Navy representatives to participate in the evaluation of technology implementation. The approach for project performance will include use of Type I –In house, organic capabilities, and Type II Existing Contact. A Type II Existing Contractual Agreement is expected to be utilized for this project two months after receipt of funds.

**3. COST/BENEFITS ANALYSIS Development Project Budget**

**a. Funding ($K):**

| Funding Source | OSD | Matching |
|---|---|---|
| Labor | 310 | 360 |
| Materials/Contracting | 850 | 850 |
| Travel | 55 | 55 |
| Report | 35 | 35 |

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| | | |
|---|---|---|
| Air Force/Navy Participation | 50 | -- |
| TOTAL ($K) | 500 | 1000 |

The $1.5M total budget is realistic and adequate for the project scope. The budget has been developed based on a detailed needs assessment for the three implementation sites. The project costs are extrapolated from ERDC-CERL's extensive previous experience in the area of industrial water treatment.

b. Return-On-Investment Computation:

1) Projected Useful Life Savings (ULS) is equal to the "Net Present Value (NPV) of Benefits and Savings" calculated from the Spreadsheet shown in Appendix 1 that is based on Appendix B of OMB Circular A94.

ULS= $15,510K (from OMB Spreadsheet in Appendix 1. Assumptions for this calculation are also given in Appendix 1).

2) Project Cost (PC) is shown as "Investment Required" in OMB Spreadsheet in Appendix 1; PC= $1,500K.

$$\text{Potential ROI} = \frac{\text{ULS}}{\text{PC}} = \frac{\$15{,}510\text{K}}{\$\,1{,}500\text{K}} = 10.34$$

The calculated ROI for this project, which is based on current best practices, projected maintenance and rehab cost, has the potential to increase over the multiple year implementation due to reduction in down time, which will result in increased indirect savings.

**c. Mission Criticality**: The operational benefits of implementation of this technology for these mission critical systems are enhanced thermal efficiency, life cycle costs, lower operating costs, reliability, safety, and environmental protection for heating and cooling distribution systems.

**4. SCHEDULE**

MILESTONE CHART

| EVENT | TIME (months after receipt of funds) |
|---|---|
| Award Contract | 2 |
| Site Visit to Determine Initial Operating Parameters | 2 |
| Install Smart Control System | 4 |
| Begin Inhibitor Application and Monitoring | 5 |
| Complete Documentation (includes Final Report, Procurement Specification, Ad Fliers) | 24 |

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| | |
|---|---|
| Complete ROI Validation | 24 |

**a. Note:** If project is approved, *bi-monthly status reports will be submitted* (i.e. starting the first week of the second month after contract award and every two months thereafter until final report is completed). This report will be submitted to the DoD CPC Policy & Oversight office. Report will include project number, progress summary (and/or any issues), performance goals and metrics and upcoming events.

**b.** Examples of performance goals and metrics: include achieving specific milestones, showing positive trend toward achieving the forecasted ROI, reaching specific performance quality levels, meeting test and evaluation parameters, and/or successfully demonstrating a new system prototype.

**Development Project Schedule**

This project to implement non-hazardous corrosion inhibitors and a smart control system on heating and cooling plants will be completed, including final report, within 18 months. **The goals of the project are: improving the reliability and reducing the cost of operating and maintaining boilers and cooling towers by using non-hazardous corrosion inhibitors and a smart control system. The objective is proper design and installation of the chemical feed and control system, and continuous operation and chemical feed.** Detailed milestones are given in the schedule section. Implementation of the chemical treatment system will be accomplished by Contractors. ERDC-CERL will provide overall management, contract monitoring and provide bi-monthly reports. Existing contract mechanisms, such as IDIQ and BAA will be used. ERDC-CERL will be able to award the contracts within 60 days of receipt of funds. The schedule has been coordinated with Fort Rucker, Fort Wainwright and West Point. Potential contractors have been identified.

**5. IMPLEMENTATION**

**a. Transition approach**: Unified Facilities Guide Specifications (UFGS), Engineering Instructions (EI), Technical Instructions (TI), and Technical Manuals (TM), including updates, along with a final report describing the details of the project, will be developed and posted on the OSD Corrosion Exchange website under "Spec & Standards" and "Facilities SIG." In addition, the draft documents will be posted on the ERDC-CERL Corrosion Prevention and Control Program (CPCP) website. Coordination with potential users will be an essential part of the transition of the technology.

It is the intent of the Project Management Plan (PMP) to implement this corrosion prevention and control technology at multiple regions and installations over the next 4 years. The UFGS, EIs, TIs, and TMs, including updates to existing guidance documents, developed for Army-wide implementation during the FY06 project, will be utilized to facilitate the planned implementation over the next 4 years.

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**b. Potential ROI validation**: ROI will be validated by comparison of operating parameters for the boilers, cooling towers, and distribution systems before and after the installation of the smart control system and non-hazardous corrosion inhibitors during the first two years of implementation. In subsequent years, the extension of useful and energy efficient service life of the heat distribution system will be used to calculate the ROI. The ROI will be validated by an impartial NACE-certified Corrosion Expert such as John Fitzgerald (Past President of NACE) or similarly-qualified person suggested by NACE Headquarters.

**c. Final Report**: A final report will be written 60 days after the project is completed. The report will reflect the project plan format as implemented and will include lessons learned.

**Projected Benefits:**
Based on the past record of demonstrating these technologies at Army installations, advanced non-hazardous chemical treatments and a smart control system would provide the benefits of maintaining optimum operating conditions for boilers and cooling towers, as well as reduced maintenance and increased safety. Downtime of heating and cooling systems has a significant impact on mission execution.

**Operational Readiness**
The non-hazardous inhibitors and smart control system technologies are commercially available and ready for implementation as solutions to the corrosion problems of the heating systems at the three sites. Based on previous experience, this project will enhance the performance, reliability and safety of the heating and cooling plants.

**Management Support**
This project enjoys the support of the Fort Rucker, Fort Wainwright and West Point DPW Offices, specifically, Tommy Baldwin at Fort Rucker, Mr. Pat Driscoll at Fort Wainwright, and Mr. Steve Driver at West Point. HQ-IMA and HQ-ACSIM are supporting this project, as shown on the coordination sheet. Moreover, the Army (HQ-IMA) has planned to provide matching funds ($1,000K for this project) for FY06. See attached Memorandum from ACSIM Director for Facilities and Housing in Appendix 2.

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**CORROSION PREVENTION AND CONTROL PROJECT PLAN**

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## 6. COORDINATION SHEET

| ORGANIZATION | SIGNATURE | DATE |
|---|---|---|
| Associate Project Manager | [illegible] | 14 Jan 05 |
| Project Manager | Vincent F Hock | 14 June 05 |
| ERDC/CERL Branch Chief | Martin Savoie | 14 June 05 |
| Ft. Rucker DPW POC | | |
| Ft. Wainwright DPW POC | | |
| U.S. Military Academy DPW POC | | |
| IMA Southeast Region | | |
| IMA Northwest Region | | |
| IMA Northeast Region | | |
| HQ IMA | | |
| HQ ACSIM | | |
| HQ AMC | | |
| Tri Service Facilities WIPT Chair | | |

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| Associate Project Manager | | |
| Project Manager | | |
| ERDC/CERL Branch Chief | | |
| Ft. Rucker DPW POC | | |
| Ft. Wainwright DPW POC | [illegible] | 27 Sep 05 |
| U.S. Military Academy DPW POC | | |
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| ERDC/CERL Branch Chief | | |
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| Ft. Wainwright DPW POC | | |
| U.S. Military Academy DPW POC | [signature] | 9/29/05 |
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| Ft. Rucker DPW POC | | |
| Ft. Wainwright DPW POC | | |
| U.S. Military Academy DPW POC | | |
| IMA Southeast Region | Steve Jackson | 9-28-2005 |
| IMA Northwest Region | | |
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| IMA Southeast Region | | |
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| Ft. Wainwright DPW POC | | |
| U.S. Military Academy DPW POC | | |
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| IMA Northwest Region | | |
| IMA Northeast Region | | |
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|---|---|---|
| Associate Project Manager | /s/ | 14 JAN 05 |
| Project Manager | /s/ | 14 JAN 05 |
| ERDC/CERL Branch Chief | /s/ | 14 JAN 05 |
| Ft. Rucker DPW POC | Approved, waiting sig | |
| Ft. Wainwright DPW POC | /s/ | 27 Sept 05 |
| U.S. Military Academy DPW POC | Approved, waiting sig | |
| IMA Southeast Region | /s/ | 28 Sept 05 |
| IMA PARO Region | /s/ | 28 Sept 05 |
| IMA Northeast Region | /s/ | 27 Sept 05 |
| HQ IMA | /s/ | 15 June 05 |
| HQ ACSIM | /s/ | 15 June 05 |
| HQ AMC | [signature] | 29 Sept 05 |
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in Heating and Cooling Systems

APPENDIX 1

POTENTIAL ROI CALCULATIONS BASED ON OMB CIRCULAR A94

**West Point Chillers**

West point operates 15 closed loop chiller systems with evaporative cooling towers. The current costs include hazardous waste disposal and cleanup costs that are avoided with the replacement products. West Point is experiencing corrosion problems with all of these systems. The estimated costs for the existing system and the "green chemistry" approach are as follows:

| | |
|---|---|
| Current Annual Operating Costs | $ 360 K |
| Average Annual Costs For Repair, Replacement Of Components | $ 125 K |
| Total Baseline Costs (Column B) | $ 485 K |
| Annual Operating Costs of New System (Column D) | $ 285 K |
| Benefits/Saving of New System – Indirect Cost Avoided* (Column E) | $ 310 K |

* Indirect costs are the costs of mission impact and alternative accommodations made in the event of a loss of heating or cooling. Heating and cooling losses greatly impact the training mission, and accommodations for providing alternate housing during heating or cooling failures can be costly.

**Fort Rucker Cooling Towers**

Fort Rucker maintains 35 cooling towers, and a similar number of boilers. The operating budget for cooling towers is $690 per year.

| | |
|---|---|
| Current Annual Operating Costs | $ 290K |
| Average Annual Costs For Repair, Replacement Of Components | $ 400 K |
| Total Baseline Costs (Column B) | $ 690 K |
| Annual Operating Costs of New System (Column D) | $ 195 K |
| Benefits/Saving of New System – Indirect Cost Avoided (Column E) | $ 125 K |

**Fort Wainwright Heat Exchangers / Building Heat Exchangers**

The current operating cost includes waste disposal and cleanup costs that are avoided with the glycol replacement product. The cost of the replacement product is equal to

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the cost of ethylene glycol, and 15% lower than propylene glycol. The price of the glycol products varies with the cost of crude oil, much as the price of gasoline at the pump. The cost of the replacement product is comparably stable.

| | |
|---|---|
| Current Annual Operating Costs | $ 100 K |
| Average Annual Costs for Repair, Replacement Of Components | $ 40 K |
| Total Baseline Costs (Column B) | $ 140 K |
| Annual Operating Costs of New System (Column D) | $ 100 K |
| Benefits/Saving of New System – Indirect Cost Avoided (Column E) | $ 100 K |

The OMB spreadsheets follow for a) the total program, b) the treatment of boilers and chillers at West Point, c) the cooling towers and boilers at Fort Rucker, and d) the heating systems at Fort Wainwright. Spreadsheet a) is simply the sum of the values of spreadsheets b), c) and d).

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## Return on Investment Calculation

| | | | |
|---|---|---|---|
| Investment Required | | | 1,500,000 |
| Return on Investment Ratio | 10.34 | Percent | 1034% |
| Net Present Value of Costs and Benefits/Savings | 7,445,220 | 22,956,095 | 15,510,875 |

| A Future Year | B Baseline Costs | C Baseline Benefits/Savings | D New System Costs | E New System Benefits/Savings | F Present Value of Costs | G Present Value of Savings | H Total Present Value |
|---|---|---|---|---|---|---|---|
| 1 | 1,315,000 | | 600,000 | 535,000 | 560,760 | 1,729,010 | 1,168,250 |
| 2 | 1,315,000 | | 600,000 | 535,000 | 524,040 | 1,615,790 | 1,091,750 |
| 3 | 1,315,000 | | 600,000 | 535,000 | 489,780 | 1,510,155 | 1,020,375 |
| 4 | 1,315,000 | | 600,000 | 535,000 | 457,740 | 1,411,365 | 953,625 |
| 5 | 1,315,000 | | 600,000 | 535,000 | 427,800 | 1,319,050 | 891,250 |
| 6 | 1,315,000 | | 600,000 | 535,000 | 399,780 | 1,232,655 | 832,875 |
| 7 | 1,315,000 | | 600,000 | 535,000 | 373,620 | 1,151,995 | 778,375 |
| 8 | 1,315,000 | | 600,000 | 535,000 | 349,200 | 1,076,700 | 727,500 |
| 9 | 1,315,000 | | 600,000 | 535,000 | 326,340 | 1,006,215 | 679,875 |
| 10 | 1,315,000 | | 600,000 | 535,000 | 304,980 | 940,355 | 635,375 |
| 11 | 1,315,000 | | 600,000 | 535,000 | 285,060 | 878,935 | 593,875 |
| 12 | 1,315,000 | | 600,000 | 535,000 | 266,400 | 821,400 | 555,000 |
| 13 | 1,315,000 | | 600,000 | 535,000 | 249,000 | 767,750 | 518,750 |
| 14 | 1,315,000 | | 600,000 | 535,000 | 232,680 | 717,430 | 484,750 |
| 15 | 1,315,000 | | 600,000 | 535,000 | 217,440 | 670,440 | 453,000 |
| 16 | 1,315,000 | | 600,000 | 535,000 | 203,220 | 626,595 | 423,375 |
| 17 | 1,315,000 | | 600,000 | 535,000 | 189,960 | 585,710 | 395,750 |
| 18 | 1,315,000 | | 600,000 | 535,000 | 177,540 | 547,415 | 369,875 |
| 19 | 1,315,000 | | 600,000 | 535,000 | 165,900 | 511,525 | 345,625 |
| 20 | 1,315,000 | | 600,000 | 535,000 | 155,040 | 478,040 | 323,000 |
| 21 | 1,315,000 | | 600,000 | 535,000 | 144,900 | 446,775 | 301,875 |
| 22 | 1,315,000 | | 600,000 | 535,000 | 135,420 | 417,545 | 282,125 |
| 23 | 1,315,000 | | 600,000 | 535,000 | 126,540 | 390,165 | 263,625 |
| 24 | 1,315,000 | | 600,000 | 535,000 | 118,260 | 364,635 | 246,375 |
| 25 | 1,315,000 | | 600,000 | 535,000 | 110,520 | 340,770 | 230,250 |
| 26 | 1,315,000 | | 600,000 | 535,000 | 103,320 | 318,570 | 215,250 |
| 27 | 1,315,000 | | 600,000 | 535,000 | 96,540 | 297,665 | 201,125 |
| 28 | 1,315,000 | | 600,000 | 535,000 | 90,240 | 278,240 | 188,000 |
| 29 | 1,315,000 | | 600,000 | 535,000 | 84,360 | 260,110 | 175,750 |
| 30 | 1,315,000 | | 600,000 | 535,000 | 78,840 | 243,090 | 164,250 |

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Return on Investment Calculation - Chillers at West Point

| | | | |
|---|---|---|---|
| Investment Required | | | 750,000 |
| Return on Investment Ratio | 8.44 | Percent | 844% |
| Net Present Value of Costs and Benefits/Savings | 3,536,480 | 9,864,917 | 6,328,437 |

| A<br>Future Year | B<br>Baseline Costs | C<br>Baseline Benefits/ Savings | D<br>New System Costs | E<br>New System Benefits/ Savings | F<br>Present Value of Costs | G<br>Present Value of Savings | H<br>Total Present Value |
|---|---|---|---|---|---|---|---|
| 1 | 485,000 | | 285,000 | 310,000 | 266,361 | 743,007 | 476,646 |
| 2 | 485,000 | | 285,000 | 310,000 | 248,919 | 694,353 | 445,434 |
| 3 | 485,000 | | 285,000 | 310,000 | 232,646 | 648,959 | 416,313 |
| 4 | 485,000 | | 285,000 | 310,000 | 217,427 | 606,506 | 389,079 |
| 5 | 485,000 | | 285,000 | 310,000 | 203,205 | 566,835 | 363,630 |
| 6 | 485,000 | | 285,000 | 310,000 | 189,896 | 529,709 | 339,813 |
| 7 | 485,000 | | 285,000 | 310,000 | 177,470 | 495,047 | 317,577 |
| 8 | 485,000 | | 285,000 | 310,000 | 165,870 | 462,690 | 296,820 |
| 9 | 485,000 | | 285,000 | 310,000 | 155,012 | 432,401 | 277,389 |
| 10 | 485,000 | | 285,000 | 310,000 | 144,866 | 404,099 | 259,233 |
| 11 | 485,000 | | 285,000 | 310,000 | 135,404 | 377,705 | 242,301 |
| 12 | 485,000 | | 285,000 | 310,000 | 126,540 | 352,980 | 226,440 |
| 13 | 485,000 | | 285,000 | 310,000 | 118,275 | 329,925 | 211,650 |
| 14 | 485,000 | | 285,000 | 310,000 | 110,523 | 308,301 | 197,778 |
| 15 | 485,000 | | 285,000 | 310,000 | 103,284 | 288,108 | 184,824 |
| 16 | 485,000 | | 285,000 | 310,000 | 96,530 | 269,267 | 172,737 |
| 17 | 485,000 | | 285,000 | 310,000 | 90,231 | 251,697 | 161,466 |
| 18 | 485,000 | | 285,000 | 310,000 | 84,332 | 235,241 | 150,909 |
| 19 | 485,000 | | 285,000 | 310,000 | 78,803 | 219,818 | 141,015 |
| 20 | 485,000 | | 285,000 | 310,000 | 73,644 | 205,428 | 131,784 |
| 21 | 485,000 | | 285,000 | 310,000 | 68,828 | 191,993 | 123,165 |
| 22 | 485,000 | | 285,000 | 310,000 | 64,325 | 179,432 | 115,107 |
| 23 | 485,000 | | 285,000 | 310,000 | 60,107 | 167,666 | 107,559 |
| 24 | 485,000 | | 285,000 | 310,000 | 56,174 | 156,695 | 100,521 |
| 25 | 485,000 | | 285,000 | 310,000 | 52,497 | 146,439 | 93,942 |
| 26 | 485,000 | | 285,000 | 310,000 | 49,077 | 136,899 | 87,822 |
| 27 | 485,000 | | 285,000 | 310,000 | 45,857 | 127,916 | 82,059 |
| 28 | 485,000 | | 285,000 | 310,000 | 42,864 | 119,568 | 76,704 |
| 29 | 485,000 | | 285,000 | 310,000 | 40,071 | 111,777 | 71,706 |
| 30 | 485,000 | | 285,000 | 310,000 | 37,449 | 104,463 | 67,014 |

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## Return on Investment Calculation - Cooling Towers at Ft. Rucker

Investment Required: 500,000

Return on Investment Ratio: 15.39 Percent: 1539%

Net Present Value of Costs and Benefits/Savings: 2,419,697 10,113,091 7,693,394

| A Future Year | B Baseline Costs | C Baseline Benefits/ Savings | D New System Costs | E New System Benefits/ Savings | F Present Value of Costs | G Present Value of Savings | H Total Present Value |
|---|---|---|---|---|---|---|---|
| 1 | 690,000 | | 195,000 | 125,000 | 182,247 | 761,699 | 579,452 |
| 2 | 690,000 | | 195,000 | 125,000 | 170,313 | 711,821 | 541,508 |
| 3 | 690,000 | | 195,000 | 125,000 | 159,179 | 665,285 | 506,106 |
| 4 | 690,000 | | 195,000 | 125,000 | 148,766 | 621,764 | 472,998 |
| 5 | 690,000 | | 195,000 | 125,000 | 139,035 | 581,095 | 442,060 |
| 6 | 690,000 | | 195,000 | 125,000 | 129,929 | 543,035 | 413,106 |
| 7 | 690,000 | | 195,000 | 125,000 | 121,427 | 507,501 | 386,074 |
| 8 | 690,000 | | 195,000 | 125,000 | 113,490 | 474,330 | 360,840 |
| 9 | 690,000 | | 195,000 | 125,000 | 106,061 | 443,279 | 337,218 |
| 10 | 690,000 | | 195,000 | 125,000 | 99,119 | 414,265 | 315,146 |
| 11 | 690,000 | | 195,000 | 125,000 | 92,645 | 387,207 | 294,562 |
| 12 | 690,000 | | 195,000 | 125,000 | 86,580 | 361,860 | 275,280 |
| 13 | 690,000 | | 195,000 | 125,000 | 80,925 | 338,225 | 257,300 |
| 14 | 690,000 | | 195,000 | 125,000 | 75,621 | 316,057 | 240,436 |
| 15 | 690,000 | | 195,000 | 125,000 | 70,668 | 295,356 | 224,688 |
| 16 | 690,000 | | 195,000 | 125,000 | 66,047 | 276,041 | 209,994 |
| 17 | 690,000 | | 195,000 | 125,000 | 61,737 | 258,029 | 196,292 |
| 18 | 690,000 | | 195,000 | 125,000 | 57,701 | 241,159 | 183,458 |
| 19 | 690,000 | | 195,000 | 125,000 | 53,918 | 225,348 | 171,430 |
| 20 | 690,000 | | 195,000 | 125,000 | 50,388 | 210,596 | 160,208 |
| 21 | 690,000 | | 195,000 | 125,000 | 47,093 | 196,823 | 149,730 |
| 22 | 690,000 | | 195,000 | 125,000 | 44,012 | 183,946 | 139,934 |
| 23 | 690,000 | | 195,000 | 125,000 | 41,126 | 171,884 | 130,758 |
| 24 | 690,000 | | 195,000 | 125,000 | 38,435 | 160,637 | 122,202 |
| 25 | 690,000 | | 195,000 | 125,000 | 35,919 | 150,123 | 114,204 |
| 26 | 690,000 | | 195,000 | 125,000 | 33,579 | 140,343 | 106,764 |
| 27 | 690,000 | | 195,000 | 125,000 | 31,376 | 131,134 | 99,758 |
| 28 | 690,000 | | 195,000 | 125,000 | 29,328 | 122,576 | 93,248 |
| 29 | 690,000 | | 195,000 | 125,000 | 27,417 | 114,589 | 87,172 |
| 30 | 690,000 | | 195,000 | 125,000 | 25,623 | 107,091 | 81,468 |

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## Return on Investment Calculation - Heating at Ft. Wainwright

| | |
|---|---|
| Investment Required | 250,000 |
| Return on Investment Ratio | 6.95 |
| Percent | 695% |
| Net Present Value of Costs and Benefits/Savings | 1,240,870 / 2,978,088 / 1,737,218 |

| A<br>Future Year | B<br>Baseline Costs | C<br>Baseline Benefits/ Savings | D<br>New System Costs | E<br>New System Benefits/ Savings | F<br>Present Value of Costs | G<br>Present Value of Savings | H<br>Total Present Value |
|---|---|---|---|---|---|---|---|
| 1 | 140,000 | | 100,000 | 100,000 | 93,460 | 224,304 | 130,844 |
| 2 | 140,000 | | 100,000 | 100,000 | 87,340 | 209,616 | 122,276 |
| 3 | 140,000 | | 100,000 | 100,000 | 81,630 | 195,912 | 114,282 |
| 4 | 140,000 | | 100,000 | 100,000 | 76,290 | 183,096 | 106,806 |
| 5 | 140,000 | | 100,000 | 100,000 | 71,300 | 171,120 | 99,820 |
| 6 | 140,000 | | 100,000 | 100,000 | 66,630 | 159,912 | 93,282 |
| 7 | 140,000 | | 100,000 | 100,000 | 62,270 | 149,448 | 87,178 |
| 8 | 140,000 | | 100,000 | 100,000 | 58,200 | 139,680 | 81,480 |
| 9 | 140,000 | | 100,000 | 100,000 | 54,390 | 130,536 | 76,146 |
| 10 | 140,000 | | 100,000 | 100,000 | 50,830 | 121,992 | 71,162 |
| 11 | 140,000 | | 100,000 | 100,000 | 47,510 | 114,024 | 66,514 |
| 12 | 140,000 | | 100,000 | 100,000 | 44,400 | 106,560 | 62,160 |
| 13 | 140,000 | | 100,000 | 100,000 | 41,500 | 99,600 | 58,100 |
| 14 | 140,000 | | 100,000 | 100,000 | 38,780 | 93,072 | 54,292 |
| 15 | 140,000 | | 100,000 | 100,000 | 36,240 | 86,976 | 50,736 |
| 16 | 140,000 | | 100,000 | 100,000 | 33,870 | 81,288 | 47,418 |
| 17 | 140,000 | | 100,000 | 100,000 | 31,660 | 75,984 | 44,324 |
| 18 | 140,000 | | 100,000 | 100,000 | 29,590 | 71,016 | 41,426 |
| 19 | 140,000 | | 100,000 | 100,000 | 27,650 | 66,360 | 38,710 |
| 20 | 140,000 | | 100,000 | 100,000 | 25,840 | 62,016 | 36,176 |
| 21 | 140,000 | | 100,000 | 100,000 | 24,150 | 57,960 | 33,810 |
| 22 | 140,000 | | 100,000 | 100,000 | 22,570 | 54,168 | 31,598 |
| 23 | 140,000 | | 100,000 | 100,000 | 21,090 | 50,616 | 29,526 |
| 24 | 140,000 | | 100,000 | 100,000 | 19,710 | 47,304 | 27,594 |
| 25 | 140,000 | | 100,000 | 100,000 | 18,420 | 44,208 | 25,788 |
| 26 | 140,000 | | 100,000 | 100,000 | 17,220 | 41,328 | 24,108 |
| 27 | 140,000 | | 100,000 | 100,000 | 16,090 | 38,616 | 22,526 |
| 28 | 140,000 | | 100,000 | 100,000 | 15,040 | 36,096 | 21,056 |
| 29 | 140,000 | | 100,000 | 100,000 | 14,060 | 33,744 | 19,684 |
| 30 | 140,000 | | 100,000 | 100,000 | 13,140 | 31,536 | 18,396 |

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**ARMY FACILITIES**
**CORROSION PREVENTION AND CONTROL PROJECT PLAN**
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**in Heating and Cooling Systems**

| | | | | | | | | New Sytem Cost | | | | Benefits | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | A | | B | | C | | Total | A | B | C | Total | A | B | C | Total |
| | Operate | Repair | Operate | Repair | Operate | Repair | | | | | | | | | |
| 1 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 2 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 3 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 4 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 5 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 6 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 7 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 8 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 9 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 10 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 11 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 12 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 13 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 14 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 15 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 16 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 17 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 18 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 19 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 20 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 21 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 22 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 23 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 24 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 25 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 26 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 27 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 28 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 29 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |
| 30 | $360,000 | $125,000 | $290,000 | $400,000 | $100,000 | $40,000 | $1,315,000 | $285,000 | $195,000 | $120,000 | $600,000 | $310,000 | $125,000 | $100,000 | $535,000 |

TRI-SERVICE PROGRAM
ARMY FACILITIES
CORROSION PREVENTION AND CONTROL PROJECT PLAN
Green Water Treatment Combined with Smart Management System
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APPENDIX 2

**DEPARTMENT OF THE ARMY**
ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT
600 ARMY PENTAGON
WASHINGTON DC 20310-0600

25 MAR 2005

DAIM-FD S: 15 Oct 2005

MEMORANDUM FOR DIRECTOR, INSTALLATION MANAGEMENT AGENCY, 2511 JEFFERSON DAVIS HIGHWAY, ARLINGTON VA 22202-3926

SUBJECT: FY 06 Army Corrosion Control Program

1. OSD has tentatively allocated a total of $15.0M in FY 06 matching funds for implementation of corrosion prevention and control projects for equipment and facilities. The enclosed list of Army projects, totaling $13.3M, will be presented for approval to OSD in April 05.

2. The Army programming target is not less than $10.0M of facility related projects in an effort to obtain a minimum of $5.0M of the OSD matching funds. To participate in OSD's funding augumentation, HQIMA will reserve $5.0M in FY06 OMA funds, to be released to ERDC-CERL upon confirmation by this office that OSD matching funds are available. Further instructions on the actual distribution of funds will follow at that time.

3. POC for this action is Mr. David N. Purcell, or (703) 601-0371, David.Purcell@hqda.army.mil.

4. Quality Facilities for Quality Soldiers!

FOR THE ASSISTANT CHIEF OF STAFF FOR INSTALLATION MANAGEMENT:

Encl
as

MARK A. LORING
Colonel, GS
Director, Facilities and Housing

CF:
DACSIM

# Appendix B: Contractor Documentation

WORK PLAN
PRIME CONTRACT: W9132T-06-D-0001
06T0158, TASK 1

## MIOX MIXED OXIDANT PROCESS

Background: A new disinfectant process has been developed to replace chlorination in cooling water systems. The MIOX process, manufactured by the MIOX Corporation in Albuquerque, NM, replaces chlorine gas and bulk bleach disinfecting systems. The process eliminates biofouling and reduces corrosion and scaling. Existing biofilm is removed, and microbiologically-induced corrosion and corrosion due to sulfate-reducing bacteria are greatly reduced. This technology is to be demonstrated at the Corpus Christie Army Depot, Corpus Christie, Texas.

Contractors: The prime contractor is:

Mandaree Enterprise Corporation
812 Park Drive
Warner Robins, GA
Phone: 478-329-8233
Fax: 478-329-8946
Larry Cranford
Senior Contract Administrator

Subcontractors:

SurTech Corporation
PO Box 90406
Indianapolis, Indiana 46290-0406
317-254-9483
Fax: 317-254-1344
www.surtechcorp.com

e-mail: hbrugman@surtechcorp.com
Principle Scientist: Helmut H Brugman – 35 years experience as a water treatment specialist.

Subcontractors to SurTech Corporation:

MIOX Corporation: 5601 Balloon Fiesta Pkwy NE Albuquerque, NM 87113-2101, US

Technicians and experience: One of the following people will be at CCAD to help with installation and startup. Availability at time of startup determines who will be sent.

Kevin Hoeschen--- Senior Technician, has been with MIOX for 5 years working on OSG systems, both in installing, repair and maintaining of systems.

Terry Nauman---Has been with MIOX for 3 years working on OSG systems, both in installing, repair and maintaining of systems.

Ernesto Moreno--- Has been with MIOX for over 6 years as a production technician, main responsibilities are to assemble and test all equipment.

Santiago Tapia—Has been with MIOX for 1 and ½ years as a production technician, mains responsibilities are to assemble and test all equipment.

Brian Hall--- Has been MIOX for 4 months as a production technician, main responsibilities are to assemble and test all equipment.

Steve Garcia--- Customer Service Manager, has been with MIOX for 6 months. Responsibilities include day to day operations, support of customer requests, logistics for service team.

Fort Bend Services: 13303 Redfish Lane, Stafford, Texas - (281) 261-5199. This is a full service water treatment contractor who will monitor the progress at CCAD on a regular basis, taking samples, testing, installing and removing corrosion coupons and reporting to SurTech Corp. Their service representative is Curtis Junge who has 35 years experience. Mr. Junge will be the on-site service representative for this project.

Foss Enterprises: PO Box 9781 Woodsboro, TX 78469. 361-813-0008. Foss Enterprises is a local mechanical contractor that has been in business over 20 years. The owner, Kevin Foss, has worked on previous projects at CCAD. They will assist in the delivery and installation of the MIOX units. Kevin Foss will be responsible for electrical, and water line hookups from each condenser water supply and to each condenser water return. Vents will be installed at each machine room along with the corrosion monitoring equipment.

Work to be done:

CCAD: Needs to provide access to the machine rooms at MR-9, MR-95, Hydraulics, and Engine Test Cell 13. The base will need to provide personnel to advise while SurTech will approve electrical hookups, water connections, and location of roof vents. We will need the following electrical connection:

The SAL system is configured for nominal 220 VAC single-phase power at either 50 or 60 Hz. The unit comes equipped with a NEMA-standard 6L-30 male lug. While the system operates at 5A for the SAL-30, and 6-7A for the SAL-40, the circuit requirement for the power outlet is greater in order to handle inrush current loads. The three SAL units require 20 amp circuits. The units are equipped with an integral switch/circuit breaker that is located on the lower left, outside panel of the control box.

MIOX units SAL-30 and SAL-40 will be installed at MR-9, MR-95, and the Hydraulics Machine Room. Engine Test Cell 13 will be used as a control. The installation and operation manuals for the MIOX units are in Attachment 1. We anticipate installing one SAL 30 at Hydraulics and One SAL 40 each at MR-9 and MR-95. The SAL 30 can generate up to 2.5 Lbs per day equivalent of free available chlorine and the SAL 40 can generate up to 4.0 Lbs per day of free available chlorine. The input ingredients are soft water, sodium chloride salt, and electricity. Water and salt are on the USFDA GRAS list (generally regarded as safe). The MSDS for the generated mixed oxidants can be found on page 116 the SAL Manual. On site adjustments will be necessary to set the flow needed at each site. The free available chlorine residual will be targeted initially for 0.5-1.0 mg/l.

The installation team will be responsible for all parts of the installation except electrical supply. The following electrical conditions are required:

- Reliable and transient free power
- Proper grounding
- Avoid ground loop conditions
- Avoid power spikes, surges, and brown-outs
- AC single phase and 50 or 60 Hz power
- Dedicated circuits for each system;
- 220 VAC conventional grounded 3-prong twist plug
- 110 VAC conventional grounded 3-prong plug

If the voltage variation to the SAL unit is greater than plus or minus 10 percent or is subject to power interruptions, electrical storms, nonstandard grounding, or harmonic effects, MIOX Corporation recommends installation of a line conditioner, UPS, or lightning arrestor in order to protect the sensitive electronics in the control box. Line conditioning equipment is available from most electrical supply stores. The warranty will be void if a system failure *can be traced to a poor power source*. If you need technical assistance, please contact your local distributor or MIOX Corporation.

All MIOX Corporation units **require** a **good earth ground**, both for personal safety and safety of the unit. The surge protection devices inside the unit are ineffective without a good earth ground. A common point earth is the green wire in our power cable. Although the equipment may have both high voltage (110 or 220 VAC) and high current, it is safe if properly wired and installed.

**All MIOX Corporation units require a good earth ground. A neutral is not a substitute for an earth ground. Electrical wiring to all MIOX Corporation units should be wired by a certified electrician and on a separate circuit from other power devices such as pumps. MIOX Corporation cannot be held responsible for units wired improperly or that fail to meet UL Standard for Safety or National Electric Code (NEC) requirements. If the unit is improperly grounded, the MIOX Corporation warranty is void. SurTech will verify that the electrical circuit is properly set up.**

## SAFETY

Attachment 2 contains the SurTech Safety Manual that we use for our employees and contractors. The safe use and installation of the MIOX units is covered on pages 57-59 of the MIOX SAL O&M Manual attached as Attachment 1.

## OPERATING PARAMETERS

The operational guidelines and parameters for the SAL 30 and SAL 40 are listed on page *xi* in the SAL O&M Manual.

## PROJECT SCHEDULE

| EVENT | TIME LINE |
|---|---|
| 1. Ship MIOX units to local contractor | 24 hrs. after plan approval |
| 2. MIOX installer and local contractor shipment to CCAD with equipment | Within 7 working days of |
| 3. Installation and startup of MIOX Units | Three days required |
| 4. Service representative from Ft. Bend | Weekly for first month |
| | Services or as needed |
| 5. Service representative thereafter | Every two weeks until |
| | 9/30/08 |
| 6. Report presentation | By 12/01/08 |

## DATA COLLECTION

On each service visit, the on-site chemical contractor, Fort Bend Services, will perform the following tests as a minimum on each treated system and the control:

Tower Water-

1. Calcium Hardness - record
2. Total Alkalinity - record
3. pH - 7.0-9.0
4. Specific Conductivity- 3500 micromhos maximum
5. Total Available Free Chlorine – 0.5-1.0 mg/l
6. Total Bacteria – 1000 CFU
7. Inhibitor Concentration
8. Corater Corrosion Readings for Iron (3.0mpy max.) and Copper (0.10 mpy max.)
9. Optional Tests- Iron, Copper

Makeup Water-

1. Calcium Hardness - Water softened by MIOX to 0-3 mg/l
2. Total Alkalinity – record, not significant
3. pH - 7.0-9.0
4. Specific Conductivity - record
5. Total Available Free Chlorine - record
6. Total Bacteria - record
7. Optional Tests- iron, copper

Once per month the on-site chemical contractor, Fort Bend Services, will:

1. Remove and install one copper and one steel corrosion coupon and send removed coupon to the Illinois State Water Survey.
2. Take water samples from the makeup water and each of the three test towers and the control tower and send them to the Illinois State Water Survey.

This testing program will commence 1/1/2008 and terminate 9/30/2008.

## SAFETY HAZARDS

The chemical precursors for the MIOX process are soft water and salt (sodium chloride). Both chemicals are generally regarded as safe. If a spill occurs from the oxidant solution that is manufactured from the MIOX unit, it can be washed away with clean water. The operation and maintenance of the MIOX system will be the responsibility of SurTech Corporation and its team. The system will be checked weekly by one of our team following the initial startup for one month. Service will be every 2-4 weeks thereafter. CCAD operations personnel should have at least one person who is generally familiar with the MIOX system. A CCAD worker should make daily visual inspections of the system and any concerns immediately called to the attention of Curtis Junge of Ft. Bend Service and Helmut Brugman of SurTech Corporation.

## INSTALLATION, OPERATIONAL AND MAINTENANCE WARNINGS AND CAUTIONS

•Do not pipe the water softener discharge contamination of the electrolytic cell, and dilution of the on-site oxidant solution.

•The water softener should remain upright at all times; otherwise the ion exchange resin can leak out and cause a slipping hazard.

• Oxidant solutions that are not stored in a covered container will lose their disinfecting power after 30 minutes. MIOX solution that has been properly stored may be used for disinfection for up to 5 days.

•If you have excessive stops and starts, the on-site oxidants will be diluted with startup and shutdown flushes. This can be corrected by installing a longer float level sensor.

• Do NOT use salt that contains manganese as a contaminant, rust inhibitors/iron removal agents, or free-flowing agents. These will damage the MIOX cell. SurTech will provide the proper salt.

•During the first few weeks of operation, it is critical to check the MIOX system more frequently to identify and solve site-specific problems, fine

tune the injection rate, and tighten any connections that may have loosened during shipping or use. SurTech will perform this operation.

•Remember to always add acids into water—NEVER ADD WATER INTO ACIDS.

•Use rubber gloves and safety goggles when working with acids.

•Do not allow Spears blue 75 thread sealant or pipe compound to enter the pump gears.

•Avoid excess water spray to surrounding equipment.

**OXIDANT SOLUTION WARNINGS AND PRECAUTIONS**

• The on-site oxidant solution is a disinfectant—NOT DRINKING WATER—and therefore should NOT be consumed without diluting it with water. On-site oxidant solution is not a desalinization device for making fresh water from salt water, but instead uses salt water in making the on-site oxidant solution (a disinfecting solution).

• Do not add other chemicals to the brine or oxidant tanks.

**ELECTRICAL WARNINGS AND PRECAUTIONS**

• Normal precautions should be taken with regard to electrical components in the vicinity of a water source. The control box should be disconnected from the power source before opening. SurTech will verify this.

• Do not defeat or tamper with electrical interlocks or lockout mechanisms.

• All MIOX Corporation units require a good earth ground. A neutral is not a substitute for a proper earth ground. Electrical wiring to all MIOX Corporation units should be performed by a certified electrician. The circuit should be separated from other power devices.

• SurTech will verify conformance with all electrical codes and standards. The MIOX Corporation warranty is void if codes and standards are not followed.

• If the voltage variation to the SAL unit is greater than plus or minus 10 percent or is subject to power interruptions, electrical storms, nonstandard grounding, or harmonic effects, MIOX Corporation recommends installation of a line conditioner, uninterruptible power supply (UPS), or lightning arrestor in order to protect the sensitive electronics in the control box.

## HYDROGEN GAS WARNINGS AND PRECAUTIONS

• Any process that involves electrolysis of water liberates hydrogen gas. Hydrogen gas could cause an explosive situation if ignited in an oxygen atmosphere. Proper venting of the oxidant tank is mandatory.

• Ensure that NO flames or ignition sources are in or around the tank. SurTech will verify.

• Always assume hydrogen is in and around the oxidant tank. Remove the oxidant tank lid and vent the tank at least one hour prior to tank maintenance and ensure that the facility is adequately ventilated.

• A liquid barrier hydrogen or dilution air vent system is mandatory. SurTech will verify that all hydrogen vent lines slope down towards the oxidant tank.

• Ensure that no valves, drop legs or P-traps are in the hydrogen vent lines. Do NOT cross connect vent lines. SurTech will verify.

• Ensure that oxidant tanks are labeled properly.

• Always follow the plumbing and venting procedures recommended by MIOX Corporation. Consult MIOX Corporation or an engineering professional prior to making changes to piping in oxidant tanks. SurTech will approve all changes.

# ATTACHMENT 1
# MIOX SAL MANUAL

MIOX

# SAL-30, SAL-40, and SAL-80

## *Installation, Operation & Maintenance Manual*

MIOX September 29, 2006

MIOX Corporation certifies this instrument was tested thoroughly, inspected, and found to meet minimum specifications when it was shipped from the factory.

MIOX Corporation maintains a constant product improvement program that may affect design and/or specifications. The company reserves the right to make these changes without prior notice or liability. Portions of the MIOX systems are covered by U.S. patent.

It is the responsibility of the operator to ensure that the MIOX water disinfection unit is properly operated in accordance with the instructions in this manual.

**NOTE: In order to ensure optimal performance of the equipment, MIOX Corporation strongly recommends that the operators of the system read and understand this manual prior to installation and use.**

**System Serial Number(s):** ____________________
**Cell Serial Number(s):** ____________________
**Installed by:** ____________________
**Installation Date:** ____________________
**Installation Location:** ____________________
**Manual Part Number:** 102-00054____________________
**For assistance, contact your MIOX sales agent or MIOX Customer Support.**
**Name:** ____________________
**Phone:** ____________________
**Fax:** ____________________
**Email:** ____________________

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## LIST OF FIGURES



## LIST OF TABLES

# WARNINGS AND PRECAUTIONS

The following **WARNINGS** and **PRECAUTIONS** must be heeded:

- On-site generation equipment is classified by OSHA as Class I, Division 2, Group B equipment. Ensure that the facility and the equipment installation is in conformance with all codes and standards. Untrained persons should not attempt to install or operate SAL systems.
- Ensure that all equipment is located in a secure location to avoid uncontrolled access or tampering to the unit or water supply.

OXIDANT SOLUTION WARNINGS AND PRECAUTIONS

- The on-site oxidant solution is a disinfectant—NOT DRINKING WATER—and therefore should NOT be consumed without diluting it with water. On-site oxidant solution is not a desalinization device for making fresh water from salt water, but instead uses salt water in making the on-site oxidant solution (a disinfecting solution).
- It is critical to use the correct amount of on-site oxidant solution in the raw water in order to adequately remove any water-borne microorganisms that may cause illness or death. MIOX recommends consulting a professional for proper dose rates. It is the operator's responsibility to ensure adequate dosing and maintenance of a chlorine residual in the water distribution system.
- Do not add other chemicals to the brine or oxidant tanks.

ELECTRICAL WARNINGS AND PRECAUTIONS

- Normal precautions should be taken with regard to electrical components in the vicinity of a water source. The control box should be disconnected from the power source before opening.
- Do not defeat or tamper with electrical interlocks or lockout mechanisms.
- All MIOX Corporation units require a good earth ground. A neutral is not a substitute for a proper earth ground. Electrical wiring to all MIOX Corporation units should be performed by a certified electrician. The circuit should be separated from other power devices.
- Verify conformance with all electrical codes and standards. The MIOX Corporation warranty is void if codes and standards are not followed.
- If the voltage variation to the SAL unit is greater than plus or minus 10 percent or is subject to power interruptions, electrical storms, nonstandard grounding, or harmonic effects, MIOX Corporation recommends installation of a line conditioner, uninterruptible power supply (UPS), or lightning arrestor in order to protect the sensitive electronics in the control box.

HYDROGEN GAS WARNINGS AND PRECAUTIONS

- Any process that involves electrolysis of water liberates hydrogen gas. Hydrogen gas could cause an explosive situation if ignited in an oxygen atmosphere. Proper venting of the oxidant tank is mandatory.
- Ensure that NO flames or ignition sources are in or around the tank.
- Always assume hydrogen is in and around the oxidant tank. Remove the oxidant tank lid and vent the tank at least one hour prior to tank maintenance and ensure that the facility

is adequately ventilated.

- A liquid barrier hydrogen or dilution air vent system is mandatory. Ensure that all hydrogen vent lines slope down towards the oxidant tank.
- Ensure that no valves, drop legs or P-traps are in the hydrogen vent lines. Do NOT cross connect vent lines.
- Ensure that oxidant tanks are labeled properly.
- Always follow the plumbing and venting procedures recommended by MIOX Corporation. Consult MIOX Corporation or an engineering professional prior to making changes to piping in oxidant tanks.

INSTALLATION, OPERATIONAL AND MAINTENANCE WARNINGS AND CAUTIONS

- Do not pipe the water softener discharge contamination of the electrolytic cell, and dilution of the on-site oxidant solution.
- The water softener should remain upright at all times; otherwise the ion exchange resin can leak out and cause a slipping hazard.
- Oxidant solutions that are not stored in a covered container will lose their disinfecting power after 30 minutes. MIOX solution that has been properly stored may be used for disinfection for up to 5 days.
- If you have excessive stops and starts, the on-site oxidants will be diluted with startup and shutdown flushes. This can be corrected by installing a longer float level sensor.
- Do NOT use salt that contains manganese as a contaminant, rust inhibitors/iron removal agents, or free-flowing agents. These will damage the MIOX cell.
- During the first few weeks of operation, it is critical to check the MIOX system more frequently to identify and solve site-specific problems, fine tune the injection rate, and tighten any connections that may have loosened during shipping or use.
- Remember to always add acids into water—NEVER ADD WATER INTO ACIDS.
- Use rubber gloves and safety goggles when working with acids.
- Do not allow Spears blue 75 thread sealant or pipe compound to enter the pump gears.
- Avoid excess water spray to surrounding equipment.

**⚠DANGER**

**Indicates an imminently hazardous situation which requires immediate operator action to avert impending personal injury, equipment damage or both.**

**⚠WARNING**

**Indicates a potentially hazardous situation that could result in death or serious injury**

**⚠CAUTION**

**Indicates a potentially hazardous situation that may result in minor or moderate injury**

***NOTE***

Information that is especially significant for understanding, operating and maintaining the equipment

# OPERATING GUIDELINES

| | SAL-30 | SAL-40 | SAL-80 |
|---|---|---|---|
| **Rated Free Available Chlorine (FAC) Production** | 2.5 lbs/day<br>1.1 kg/day | 4.0 lbs/day<br>1.8 kg/day | 10.0 lbs/day<br>4.5 kg/day |
| **Rated FAC (mg/L)** | 3,000 ±15% | | |
| **System Design Flow Rate Gallons per hour (gph)** | 6 ± 1.5 | 8 ± 2 | 15 ± 6 |
| **Electrical Service** | 220 VAC, Single Phase, 20Amps<br>OR<br>110 VAC, Single Phase, 30Amps | | 220 VAC, Single Phase, 30 Amps |
| **Approximate Volts to Each Cell** | 12 VDC | | |
| **Amps to Each Cell** | 70 ± 10% | 90 ± 10% | 180 ± 10% |
| **Air Temperature Requirements** | 35 °F - 110 °F<br>2 °C - 43 °C | | |
| **Feed Water Temperature Requirements** | 50 °F - 85 °F<br>10 °C - 29 °C | | |
| **Feed Water Pressure Requirements** | 25 - 100 psi<br>172 - 689 kPa | | |
| **Dimensions per cell (W X D X H)** | 29 x 9½ x 67½ inches<br>74 x 24 x 172 cm | | |
| **Shipping Dimensions per cell (W X D X H)** | 48 x 42 x 36 inches<br>122 x 107 x 92 cm | | |
| **Shipping Weight per cell** | 150 lbs<br>68 kg | | |

# ACRONYM LIST

| | |
|---|---|
| AC | Alternating Current |
| ANSI | American National Standards Institute |
| BOD | Biochemical Oxygen Demand |
| COD | Chemical Oxygen Demand |
| COP | Controller Operating Properly |
| CPVC | Chlorinated Polyvinyl Chloride |
| CT | Concentration x Time |
| DC | Direct Current |
| FAC | Free Available Chlorine |
| HDPE | High Density PolyEthylene |
| ID | Inside Diameter |
| MCL | Maximum Contaminant Level |
| MCU | Master Control Unit |
| NC | Normally Closed |
| NEC | National Electrical Code |
| NEMA | National Electrical Manufacturers Association |
| NO | Normally Open |
| NPT | National Pipe Thread |
| NSF | National Sanitary Foundation |
| OD | Outside Diameter |
| ORP | Oxidant Reduction Potential |
| OSHA | Occupational Safety and Health Administration |
| PRV | Pressure Regulating Valve |
| PVC | Polyvinyl Chloride |
| PVDF | PolyVinylidine DiFluoride |
| RMA | Return Merchandise Authorization |
| SCADA | Supervisory Control and Data Acquisition |
| TDS | Total Dissolved Solids |
| TOC | Total Organic Carbon |
| UL | Underwriters Laboratory |
| UPS | Uninterruptible Power Supply |

| | |
|---|---|
| US EPA | U.S. Environmental Protection Agency |
| VAC | Volts Alternating Current |
| VDC | Volts Direct Current |

# I. Introduction

This manual is designed to provide installation, operation and maintenance information to the water plant operator. Proper maintenance of the system will increase cell life and system performance. Follow all warning and precautions when installing, operating and maintaining your MIOX unit. Should advanced troubleshooting be required to solve a problem, please contact your MIOX customer service provider for further assistance.

## I.1. Regulatory Compliance

**U.S. Environmental Protection Agency (US EPA) –** On-site oxidants are listed as a compliance technology for water disinfection. To be listed as a compliance technology, the system must be affordable and achieve compliance with the maximum contaminant levels (MCLs), and the operator must be capable of installing and reliably operating the technology. The on-site oxidant category was added to this list in 1997 primarily based on independent research of the MIOX Corporation technology. The MIOX US EPA registration number is 69723-NM-001.

**NSF International –** MIOX Corporation maintains a policy of verification and compliance of MIOX Corporation technology for water applications. All MIOX generators and oxidant tanks are NSF/ANSI-61 listed. This standard provides the criteria used to evaluate the public health safety of materials, components, products, or systems that contact drinking water, drinking water chemicals, or both. The SAL series systems are also NSF/ANSI 50 listed for pools and spas. For details of specific NSF standards for specific MIOX Corporation equipment, please consult the MIOX Corporation. NSF listings can also be obtained through NSF international at (800) NSF-MARK, or their web site at www.nsf.org.

**State Approvals –** MIOX Corporation maintains a policy of obtaining state regulatory approval in all states where MIOX equipment is installed and operating. MIOX Corporation has never been turned down for approval in any state. For a complete list of states currently approving on-site oxidant technology, please contact the MIOX Corporation.

**List of Certifications**
EPA Registration Number: 69723-NM-001
NSF Standard 50 for pools and spas
NSF Standard 61 for all SAL systems.
NSF Standard 61 for oxidant solution tanks

## I.2. Components of the System

The MIOX system should be installed by trained technicians. After installation and system start-up the units operate automatically and self-diagnose.

The SAL Series systems are on-site oxidant generators (See Figure 1). The difference between the three systems is the size of the cell installed on the white PVC mounting plate. The size of the cell determines the amount of FAC generated per day: the SAL-30 system produces 2.5 pounds (1.1 kilograms) FAC per day, the Sal-40 system makes 4.0 pounds (1.8 kilograms) FAC per day, and the SAL-80 system produces 10.0 lbs. (4.5 kg) of FAC per day. When systems are linked the FAC produced per day will increase linearly. For example, two SAL-80 systems produce 20.0 (9.0 kg) pounds of FAC per day.

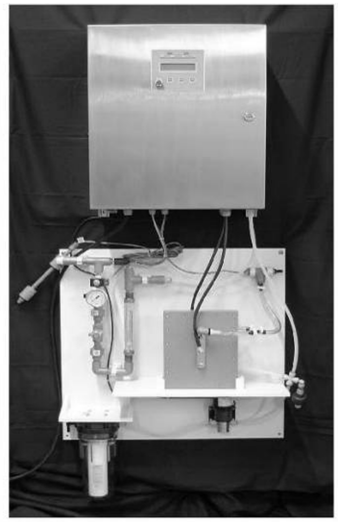


**Figure 1. Typical SAL System – cell size may vary**

### I.2.1. Space Requirements

An appropriate wall-space must be identified to accommodate the control panel and backplates of the SAL-series systems wall mounts (see Figure 3). Because the size of the cell does not effect the overall space requirements, wall and space configurations for all systems in the SAL series will be the same.

- SAL Series System Space Requirement: 3 ft. (1 m) deep by 9 ft. (3 m) wide by 6 ft. (2m) high
- SAL Series Wall Space Requirement: 3ft. (1m) wide by 6 ft. (2m) high
  Brine and oxidant tank wall space is determined by tank size, but generally consider 3ft. (1m) for each tank.
- The system should be installed on a clean and level surface.

***NOTE:* Additional floor space will be required for a solution tank and water softener and, depending on the installation, salt storage. Additional floor space will also be required for the injection system.**

### I.2.2. Security

**Enclosure and Security** – MIOX systems must be installed in a building or protected structure that provides shelter from the weather and extreme temperature variances, and which can be locked or otherwise secured. Physical security is required to ensure that unauthorized persons are denied access to the unit.

**⚠WARNING** **If the system is not adequately secured from tampering, dangerous substances that cause illness or death could be introduced into the system.**

### I.2.3. SAL System Components

**Tubing and Fittings** – All tubing and fittings shipped by MIOX Corporation meet Schedule 40 or Schedule 80 specifications. These U.S. specifications ensure that materials are rated for proper thickness, pressure resistance, and temperature resistance for the specific application.

**Water Filter** (Figure 2 A) and **Brine Filter** (Figure 2 H) – The water and brine filters are the same 5-micron external pleated cartridge filters. The water filter removes all particulate matter from the water feeding the water softener while the brine filter removes particulate matter from the brine feeding the cell. The filter housing and filter cartridge are supplied by MIOX Corporation and are required for system operation. A 10 inch (0.25 meter) industry standard filter and filter cartridge are supplied.

**Water Softener** (Figure 2 B) – All MIOX systems require soft water. Hard water will cause severe damage to the cell. Water hardness must be maintained at less than one grain (17.1 mg/L). A water softener extends the life of the electrolytic cell and helps ensure proper system operation. The softener resin is recharged with brine from the brine generator. A ¼" check valve, supplied by MIOX Corporation, should be installed on the brine regeneration line to prevent backflow of brine to the generator. The correct sized Meter Disc should be installed.

**Heater or Chiller -optional** (Figure 2 D or E) – If the feed water temperature is less than 50 °F (10 °C) or greater than 85 °F (29 °C), damage to the cell will occur. A water heater or chiller should be used to bring the water temperature into range.

**Brine Tank** (Figure 2 C) – Tanks, with lids are available in sizes ranging from 55 gallons (208 liters) to 1,000 gallons (3,785 liters). A mechanical float valve assembly which monitors the brine level is included with the brine generator.

**Control Box** (Figure 2 F) – The SAL system operates nominal on single-phase, 50 or 60 Hz, 220 VAC electric power. The SAL-30 and SAL-40 can use 110 VAC as an alternative. The control box houses the power supply, controller, and controller display (Figure 2 G). The electronic controls are designed to diagnose and adjust the unit to optimum operating conditions or shut down the system should a fault occur. A single-phase **surge arrestor** which covers lightning and transient power conditions, is built into the system.

**Electrolytic Cell** (Figure 2 I) – The proprietary membraneless electrolytic cell produces a mixture of oxidants and is manufactured by the MIOX Corporation.

**Mounting Plate Assembly** (Figure 2 J) - The mounting plate, also referred to the backplate, is pre-assembled by MIOX Corporation. The brine pump, brine filter, electrolytic cell platform, pressure switch, solenoid valve, and pressure regulating valve are all mounted on the PVC backplate prior to shipment. The entire assembly may be mounted on the wall using the Unistrut Support Installation Kit Fittings. The SAL installation kit includes four (4) pieces of Unistrut, bolts, and washers.

**Brine Pump** (Figure 2 S) - The saturated brine entering the brine pump should be filtered using the brine filter described above. This variable speed brine pump controls the volume of brine entering the electrolytic cell using a 0- to 5-volt signal from the control unit. The pump operates on 24 VDC power. A primer bulb is included in the SAL system installation kit to assist in priming the brine pump.

**Pressure Switch** – A low pressure cut-off switch with a 20 psi (138 kPa) cutoff point, the pressure switch ensures that the feed pressure is within the operational pressure range. The Pressure Regulating Valve reduces incoming fresh water pressure to 15 psi (103 pKa) for optimal system performance.

**Solenoid Valve** (Figure 2 K) – The 24 VDC solenoid valve opens to allow fresh water flow through the water manifold and cell.

**On-Site Oxidant Solution Storage Tank** (Figure 2 Q) – The storage tank is an integral part of an on-site system, and is sized to meet the injection demand at the peak hourly flow. The oxidant tank is shipped with a drop tube inside the oxidant tank. The oxidant tank must be vented directly to the atmosphere outside the facility to allow the escape of any evolved hydrogen gases.

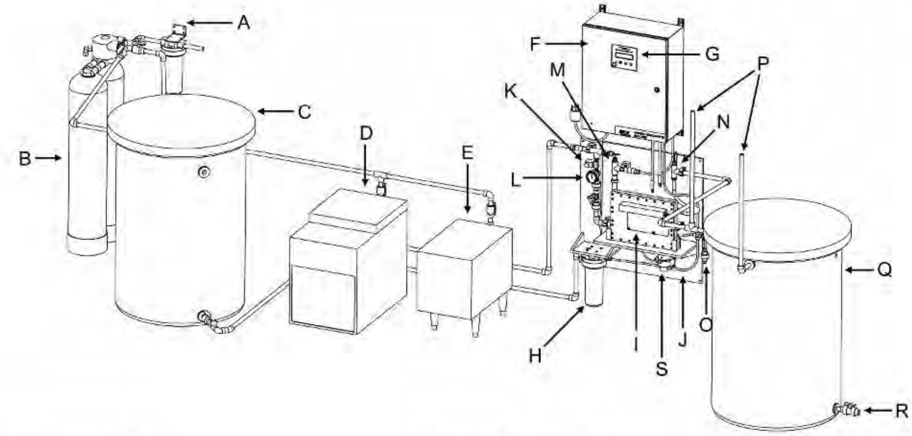
Each tank has its own Oxidant Tank Level Switch. This switch is used to turn the SAL system on when the solution tank reaches the pre-set low level and turn the system off when the solution tank reaches the high level. A switch with 6" (15.2 cm) between the high and low levels is standard equipment. Switches with 18" (45.8 cm) between the high and low levels can be special ordered, as can pressure transducers with relays and 4-20 MA outputs for SCADA Interface.

**On-site Oxidant Injection System** (optional) – If the MIOX system is intended to function as the source of final disinfection, it should be installed at the same point as a chlorine disinfection system. **It is necessary that the location of the oxidant injection point be such that proper contact time is achieved.** Normally, the MIOX solution requires the same, or less, contact time as conventional chlorine systems.

MIOX Corporation offers injection systems that can be configured to deliver the oxidants at variable or fixed rates (or times of day) into storage tanks or directly into the water line, and the design is tailored for site-specific mainline water pressure and flow. The oxidants may be injected into the water line by means of (1) a high pressure diaphragm metering pump, appropriate for variable flows, (2) a venturi injection system, appropriate for fixed flows, or (3) a centrifugal feed pump, suitable for low pressure points of injection. Because the makeup water for oxidant generation is softened water, these systems are generally maintenance-free in operation. The lack of calcium in the oxidant avoids calcium buildup on

pumps and injectors—a problem common to sodium hypochlorite or calcium hypochlorite systems.

Figure 2. Typical SAL System Components




A: Feed Water Filter
B: Water Softener
C: Brine Generator
D: Feed Water Heater
E: Float Valve Assembly
F: Control Box
G: Power Supply, Controller and Controller Display
H: Brine Filter
I Typical Electrolytic Cell
J: Mounting Plate Assembly
K: Solenoid Valve
L: Pressure Regulating Valve and Pressure Gauge
M: Cell Inlet Thermowell
N: Cell Exit Thermowell
O: Rupture Disk
P: Hydrogen Vent
Q: Solution Storage Tank
R: Outlet Fitting

# II. SAL System Installation

**⚠CAUTION** **SAFETY PRECAUTIONS AND WARNINGS** **⚠WARNING**

- On-site generation equipment is classified by OSHA as Class I, Division 2, Group B equipment. Ensure that the facility and the equipment installation are in conformance with all codes and standards. Untrained persons should not attempt to install or operate SAL systems.
- Disconnect power before working on units. *Do not reconnect the power to the control panel until installation is complete.*
- Do not defeat or tamper with electrical interlocks or lockout mechanisms.
- All MIOX Corporation units require a good earth ground. A neutral is not a substitute for a proper earth ground. Electrical wiring to all MIOX Corporation units should be performed by a certified electrician. The circuit should be separated from other power devices.
- A passive hydrogen vent system or dilution air system is mandatory. Ensure that all hydrogen vent lines slope down towards the oxidant tank.
- Ensure that no valves, drop legs or P-traps are in the hydrogen vent lines. Do NOT cross connect vent lines.
- Ensure that oxidant tanks are labeled properly.

Your MIOX system has been factory tested and must be properly installed by technicians trained by MIOX Corporation or its representatives. This chapter describes the procedures for unpacking and installing the SAL system and auxiliary equipment, including all requirements for plumbing and electrical tie-ins. Specifications and conditions regarding electrical power to the unit, water quality, water line pressure requirements, and other requirements for the installation of your unit are discussed. Most of the problems associated with start-up of a MIOX system are related to inadequately configured feed water supply, power source or poor salt quality.

**⚠CAUTION** **Untrained persons should not attempt to install or operate MIOX systems.**

## II.1. Receiving and Unpacking the System

Your MIOX system has been carefully packed to avoid shipping and handling damage. The system modules are shipped in crated pallets. Brine generator tanks, oxidant tanks, water softeners, and other ancillary equipment are shipped on pallets. Uncrate the system components and remove them from the

shipping pallet. Carefully inspect the system for any damage that may have occurred as a result of shipping. After completing a visual inspection, compare ordered items against what was delivered. Should you find anything damaged or missing please contact your MIOX sales agent or MIOX Corporation Customer Support. The components are about 12" (30 cm) wide and will fit through a standard door.
To safely unpack your SAL unit, complete the following steps.

1. **Unpack the control box**
   The control panel is packaged in its own box. Remove the control panel from the box. Set the control panel on a stable flat surface until it is ready to mount on the wall.

2. **Unpack the mounting plate**
   The mounting plate and assembled components are shipped in their own box. Remove the mounting plate from its box and place it on a stable flat surface until it is ready to mount on the wall.

3. **Unpack the cell**
   The cell is shipped in a specially designed box with appropriate padding. Check the cell for any damage that occurred during shipping. Save the box and padding materials for cell storage or shipping.

4. **Remove miscellaneous contents from the tank(s)**
   Remove the contents from the brine generator and oxidant storage tanks. At a minimum, these items include the installation kit, the solution tank level switch, the softener installation kit, and the solution tank drop tube. The components for installing a hydrogen ventilation system should also be in the tank. After removing these items, inspect the strainers inside the brine generator tank to be sure they are not damaged. If there are no strainers, they may have broken off during shipment. If installing the replacement strainers, first ensure that the fitting is not blocked by broken parts. Also inspect the float valve tube to be sure it has not been damaged during shipment.

5. **Unpack the water softener**
   Remove the water softener towers from their packaging. Do not turn the softeners over or lay them on their sides, as this will disturb the softening resin and gravel beds inside the softener and affect softener performance. The water softener metering disc is installed at the factory prior to shipment.

6. **Unpack all other equipment**
   Remove any optional components (heaters, chillers, injection systems, etc.) from their packaging and inspect for damage.

## II.2. Hardware Installation Required for Start-up

The system is designed to mount against a wall. The unit should be located so that it is near the power receptacle and allow enough room on the left side for the water softener to sit on the floor next to the unit. Do not fill the brine generator

with salt until the installation is complete. If the system needs to be moved during installation for some reason, it will be very difficult to move with salt in the tank.

A single SAL unit includes one electrolytic cell, one control box, and one mounting backplate. When multiple systems are linked together, they may utilize the same water source, water softener, brine generator and oxidant tank. It is possible to purchase dual tanks or softeners to provide redundancy.

#### II.2.1. Mounting the Control Panel

Mounting the control panel to the wall will require two people, one to hold the panel in position, and another to make the connections. The control panels are mounted via four bolt holes in the back corners of the control panels. The control panel can be mounted directly to the wall, or can be mounted on Unistrut. Be sure to drill appropriate holes in the wall and use the proper hardware for the mounting configuration of choice. The configuration will depend upon the construction of the wall. The wall material should be of sufficient strength to hold the control panel, which weighs up to 50 pounds (22.7 kg). MIOX Corporation recommends the following methods:

1) Wood screws to mount to a wooden stud wall
2) Toggle bolts for a hollow wall such as cinder block or paneling
3) Expansion anchors for concrete

Unistrut is provided in the SAL system installation kit and should be mounted horizontally on the back of the control panels. The vertical distances from the upper to lower strut and the horizontal distances between holes are shown below.

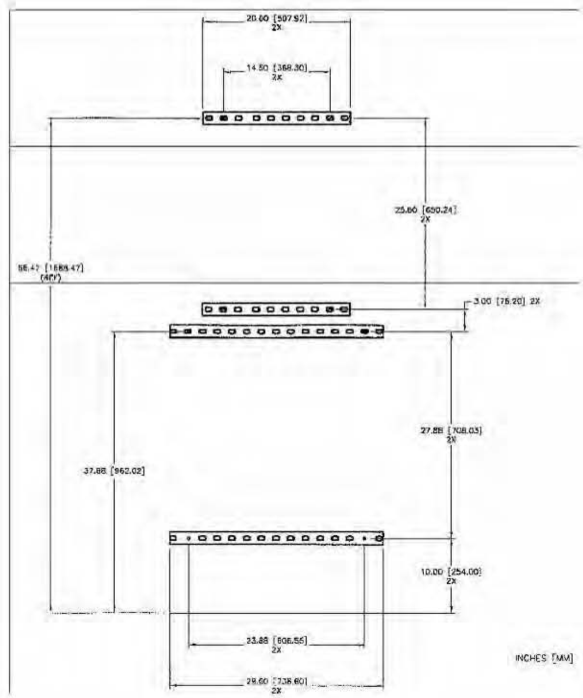



**Figure 3. Unistrut Bolt Pattern for the Control Panel and Mounting Plate**

## II.3. Electronic Connections Required for Start-up

### II.3.1. Electrical Power Connection

The SAL system is configured for nominal 220 VAC single-phase power at either 50 or 60 Hz. The unit comes equipped with a NEMA-standard 6L-30 male plug. While the system operates at approximately 5A for the SAL-30, 6-7A for the SAL-40 and 12-13 A for the SAL-80, the circuit requirement for the power outlet is greater in order to handle inrush current loads. The SAL-30, SAL-40, and systems require 20 amps while the SAL-80 systems use a 30 amp circuit. It is possible to configure the SAL-30 and SAL-40 for **30A service**, 110 VAC single phase power. The unit is equipped with an integral switch/circuit breaker that is located on the lower left, outside panel of the control box. The switch includes a waterproof cover.

Although the systems are equipped with male plugs, the system can also be wired directly to a disconnect panel or other approved electrical interface. Consult your local electrical codes. If the equipment is going to be located in an area with a high incidence of lightening strikes, the control panel can be equipped with surge protection (MOV) circuitry to protect the equipment from power spikes. Consult your distributor or the MIOX Corporation.

**⚠CAUTION Normal precautions should be taken with regard to electrical components in the vicinity of a water source. The control box should be disconnected from the power source before opening. As a safety feature, high voltages are confined to the inside of the control box enclosure. Voltages outside the control box do not exceed 24 VDC.**

***NOTE:*** Do not connect power to the system until installation is complete.

### II.3.2. Control Panel Interface Block Wiring

Heyco fittings are provided on the bottom of the control panel to facilitate field wiring of the solenoid, level switch, thermal wells, and pressure switch to the SAL system interface block. A connector is provided for the brine pump. Refer to Figure 4 for details of wiring the brine pump, pressure switch, level switch and solenoid to the interface block. Figure 5 gives more details for wiring.

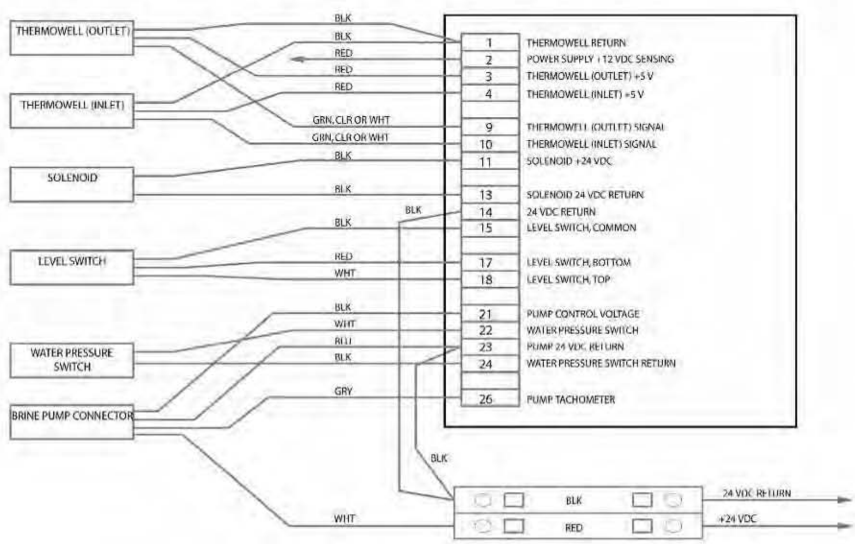



**Figure 4 Interface Block Wiring Diagram**

| PUMP | | #2 PORT |
|---|---|---|
| 1 | X | X |
| 2 | RED | +24 |
| 3 | BLACK | GROUND |
| 4 | WHITE | CONTROL |
| 5 | GREEN | TACH |

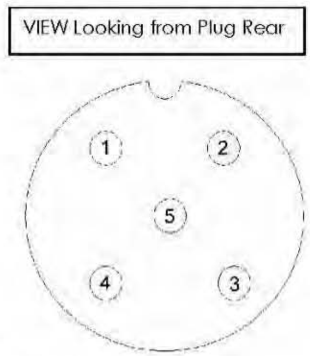



**Figure 5.** Brine Pump Connector (Pin-out)

The interface block also provides a convenient place to perform electrical diagnostics. Diagnostics can be easily accomplished with a digital volt meter.

When wiring multi-cell systems, take care not to wire and/or plumb the brine pump, cell, level switch or solenoid to different control panels. All the electrical wiring and plumbing should be between one control panel and one mounting panel. Crossing the plumbing and wiring between two control panels and mounting plates will cause the system to fail on startup. If either the plumbing or wires are crossed, the cell will never come in to the operating range because the brine pump will be feeding brine to the wrong cell. Likewise, it is important to be sure the correct solenoid valve wires are tied in to the correct control panel terminal block.

Multi-cell systems have common signal level switches. The level switches must be wired to both terminal boards inside the two control panels on these units. The simplest way to accomplish this is to wire the oxidant tank level switches to one of the terminal boards, and then to run a jumper cable (3 wires) between terminal boards in each of the control panel enclosures.

### II.3.3. Cell Installation

Remove the cell from its packaging and place it vertically into the cell support bracket on the mounting plate. The union quick disconnects are installed as follows:

- The anolyte disconnect (red marking) is connected to the top of the cell on the side marked with red tape (two port side). Attach the oxidant solution (anode) tubing to the end of the red-taped PDVF/Kynar barb fitting.

- The catholyte disconnect (black marking) is connected to the top of the cell on the side marked with black tape (single port side). Attach the catholyte tubing to the end of the black-taped PDVF/Kynar barb fitting.

For multi-cell systems, sharing an oxidant tank, the oxidant streams from both cells must be combined in a common manifold or plumbing connection so that there is only one inlet to the oxidant solution tank.

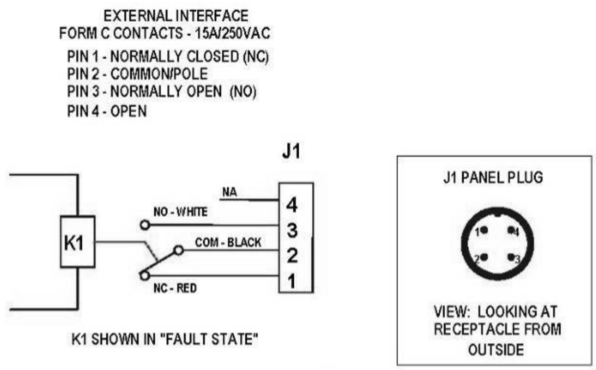
Connect the cell electrical leads, matching the red lead to the buss bar on the side of the cell with the red-taped manifold, and the black lead to the buss bar on the side of the cell with the black-taped manifold.

***NOTE:*** **To ensure a good electrical connection, do not use washers. The nuts provided with integral serrated flange will provide a good connection. Electrical conductive grease, such as Thomas & Betts "KOPR-SHIELD," should also be used and will improve the electrical connection.**

Check and tighten the ¼ - 20 cell lead/lug flange nuts to 75 inch-lbs. (8.5 newton-meters) torque. Attach the 3/8" OD quick-connect brine solution tubing into the push-in fitting at the bottom of the cell (no color-coded tape, near bottom of cell, with the tubing coming out from the brine tank). See Appendix D, "Cell Installation" for more information.

### II.3.4. Alarm Relay Wiring

The system comes wired with an alarm control circuit. This circuit can be connected to a relay circuit to lock out water system pumps, annunciate an alarm, turn on a flashing light or beacon, or activate a remote phone message or other type of signal or control. The alarm relay is located on the back panel of the control box. The relay is wired to an external connector that is mounted on the upper left side of the control box. The male portion of the connector is taped to the inside door of the control panel when shipped from the factory. The relay is a form C contact with four terminals and can be wired either normally open (NO) or normally closed (NC). The relay de-activates anytime the red fault light on the front panel display is lit. The relay will de-activate when the red fault light goes out. The wiring diagram for the alarm relay connector is shown is located in the inside door of the control panel. The relay is active in normal operate mode and is deactive when fault or power loss occurs.




| SYSTEM STATE | J1 | |
|---|---|---|
| | 1&2 | 2&3 |
| AC POWER OFF | CLOSED | OPEN |
| FAULT | CLOSED | OPEN |
| OPERATE | OPEN | CLOSED |
| STANDBY | OPEN | CLOSED |

**Figure 6. Alarm Relay Wiring Diagram**

## II.4. Plumbing Connections Required for Start-up

### II.4.1. Water Supply Tubing to Heat Exchanger

The water supply tubing is routed to the heat exchanger as shown in the general arrangement drawing (Figure 2). The tubing connections are push-in John Guest type fittings. If the tubing needs to be removed from a fitting, hold the gray collar against the fitting and pull the tube out.

***NOTE:*** **Hose dimensions referred to are inside diameters with size given in inches. Tubing dimensions are measured from the outside diameter.**

### II.4.2. Water Feed Connection

The water feed lines require only schedule 80 PVC. Only the pipes carrying on-site oxidant solution require CPVC pipe. Where possible, all connections should be solvent weld rather than threaded in order to prevent the possibility of leaks. IPS Weld-On Number 724 glue should be used. All piping should be supported at 3- to 4-foot (1 m) intervals. Isolation valves should be included on all water feed lines external to the MIOX system.

The water feed requirement is approximately 3-5.5 gph (11.3-20.8 Lph) for the SAL-30, 6-8gph (22.7-30.3 Lph) for a SAL-40 and 12-15 gph (45.4 – 56.8 Gph) for a SAL-80. The water pressure at the electrolytic cell (15 psi;103 kPa) is controlled by a pressure regulating valve (PRV). A minimum of 25 psi (172 kPa) feed water pressure is required in order to ensure a stable flow and a continuous supply of 15 psi (103 kPa) to the electrolytic cell. The PRV is factory set and should not be adjusted from the 15 psi (103 kPa) setting. This setting is critical for proper oxidant production, cell cooling, and other key operating parameters. A pressure gauge is included on the feed water manifold to visually monitor the pressure setting. The optimal feed water pressure to the system is 40 (276 kPa) to 80 psi (552 kPa). Maximum supply pressure should not exceed 100 psi (689 kPa). For supply pressure over 100 psi (689 kPa), auxiliary pressure reduction is required.

The feed water connection to the unit is a ¾" (1.9 cm) garden hose connection. The unit is shipped with a backflow preventer to preclude water from the system entering the potable water source. Installation of the backflow preventer is typically a local plumbing code requirement. The backflow preventer should be installed on the water outlet connection in the facility or building. If the backflow preventer is installed at the unit, the check valve will operate in the wrong direction. Should this occur, water will flow in the incorrect directions from the backflow preventer when the main water valve is turned on.

The water feed connection to the SAL systems will come from the water softener. The ¾" (1.9 cm) connection on the SAL system is located on the left side of the unit just under the control box. The water feed temperature must be between 50-85 °F (10 -29.4 °C) to avoid damage to the cell.

### II.4.3. Oxidant Solution Feed Line Connection

Oxidant solution comes from the anode port (marked with red tape and is combined with the cathode solution. The anolyte and catholyte feed lines (3/8" ID, 5/8" OD vinyl tubing) are attached to the red and black connectors of the cell and are then routed to the inlet port on the oxidant solution tank (See

Figure 8). The inlet port on the solution tank has the drop tube inside the tank that extends to the bottom of the tank.

For multi-cell systems, the oxidant feed lines from the electrolytic cells on each unit should be connected to a common inlet port on the oxidant solution tank. The oxidant tank is designed to force-ventilate hydrogen from the oxidant stream as it enters the oxidant tank. The oxidant streams from both cells must be combined in a common manifold or plumbing connection so that there is only one inlet to the oxidant solution tank.

**⚠WARNING Electrolysis produces hydrogen gas, which could cause an explosive situation if stored without ventilation. Proper venting of the oxidant tank is mandatory.**

### II.4.4. Brine Generator Plumbing Connections

A valve is included at the bottom of the brine generator on the tank outlet for operation and cleaning purposes.

A ½" slotted pipe strainer is provided with the brine tank. When it is properly installed on the inside of the tank, it prevents solid salt from entering the brine lines and clogging them. Install the strainer in the threaded fittings located at the inner bottom section of the tank.

The brine generator overflow port is located at the top of the brine generator. MIOX Corporation recommends using schedule 40 PVC piping to route excess brine from the overflow connection to a drain. The overflow connection is ¾" female NPT. In similar fashion, the oxidant tank overflow piping should also be routed to a drain.

The brine and oxidant tank overflows must be piped into a separate drain header than the drain header for the water softener discharge. This will prevent potential backflow up the brine and oxidant tank lines, which would fill the brine generator and oxidant tank with calcium rich brine. A common floor drain can be used as long as there are separate drain headers and an Air Gap.

## II.5. Water Softener Installation

**⚠CAUTION** **The water softener should remain upright at all times; otherwise, the ion exchange resin can leak out. This resin can create a slipping hazard if it leaks onto the floor or gets into the plumbing manifold on the system and create a maintenance problem.**

The feed water to the MIOX system must have a water hardness of less than 1 grain (1 grain = 17.1 ppm) for best system performance and for the system warranty to remain valid. Most untreated feed water will exceed this value. Without soft water, calcium carbonate in the water supply will deposit on the cell electrodes and will render the system inoperable in a short period of time.

***NOTE:*** For more information about Kinetico® water softeners, contact the manufacturer or MIOX Corporation.

MIOX Corporation uses hydraulically driven in-line dual ion exchange water softeners. While one tank regenerates, the other tank supplies softened water. Advantages of using these softeners include: trouble-free operation, continuous soft water, instantaneous switching of tanks, lower salt consumption, no electrical power usage, a selection of flow nozzles, and a check valve to prevent backflow of water from the softener to the brine generator. The softener results in an overall improvement in efficiency and cost savings. Selecting the appropriate metering disc can improve efficiency even further. For maximum water and salt use efficiency, MIOX Corporation recommends CC208, CP208, or sometimes a CP210 water softener models for use with SAL systems.

### II.5.1. Water Softener Plumbing

The Kinetico® twin-tank water softeners provided by MIOX include a water softener installation kit. The kit is shipped in the brine tank. Unpack the water softener components and the installation kit in order to begin assembly according to the steps below.

#### *II.5.1.A. Connecting the Twin Tower Tanks*

Unpack the black water softener tanks and place them approximately 6 inches (15 cm) apart with the tank connector openings facing each other. Take the two black plastic connector pipes and make sure there are two O-rings on each end. Spread the silicone gel included in kit on all O-rings. Push one connector into each opening on the first water softener tank. Next, push the connector openings of the second tank onto the other end of the connector pipes, connecting the two tanks. Place one of the two 6" metal connector links parallel to the connector pipes, on top of and between them. Next, insert a connector pin into each end of the link, and connect the two pins to the second metal connector link, placing it underneath and between the two connector pipes. This will secure the twin tower tanks together.

#### *II.5.1.B. Connecting the Water Supply to the Softener*

**Water supply to the softener can come from almost any source, including water that has been disinfected by the MIOX system. First, place O-rings on the adapter fittings provided with the water softener installation kit and spread the silicone gel evenly. Next, push one of the adapter fittings into the water softener inlet connection (**

Figure *7)*, which has an inward-pointing arrow, and place the second adapter fitting into the water softener outlet connection, which has an outward-pointing arrow, on the softener head. Place the retainer clips over these inlet and outlet connections, and secure it with the bracket pin, pushed through the top.

Next, seal the threads of the 3/4" NPT hose adapter (either an elbow or a straight hex nipple) with Spears blue 75 thread sealant and thread the adapter into the adapter fitting for the inlet connection, with the **inward-pointing arrow.** Connect the 3/4" green plastic female hose connector to the adapter. Attach the 1/2" clear braided garden hose to the green plastic connector, clamping it securely with the green plastic clamshell. The other end of the hose should be attached to the discharge of the supplied water prefilter.

***NOTE:*** **Feed water to the softener should be piped to the inlet with the inward pointing arrow on top of the water softener head. IF THE FEED WATER IS NOT CONNECTED TO THE PROPER OPENING, THE WATER SOFTENER WILL BE UNABLE TO REGENERATE and provide softened water to the MIOX system.**

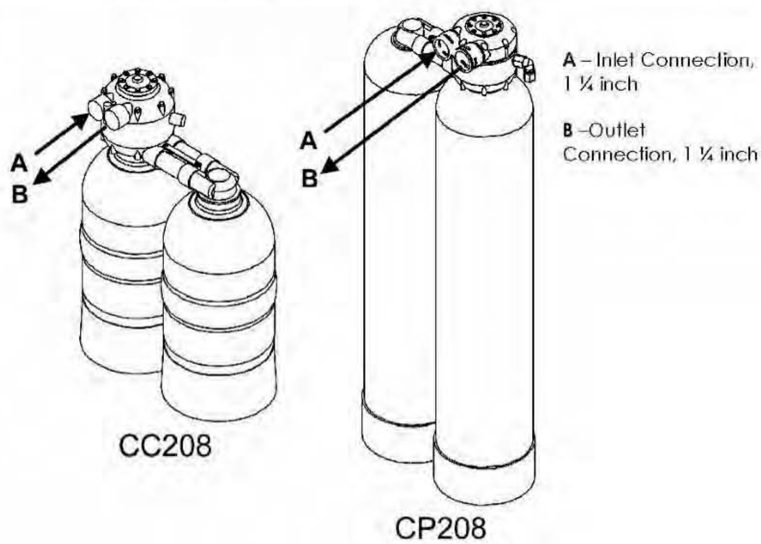


Figure 7. Representative Kinetico® Twin Tower Water Softener

***II.5.1.C. Backflow Prevention***

Most municipal and state plumbing codes require the use of a backflow preventer on any water service line that feeds a piece of equipment. The backflow preventer inhibits any fluids generated in the water softener or other piece of MIOX equipment from entering the water distribution system. The backflow preventer is a simple brass check valve type of device that screws on to the water source connection, such as a wall-mounted faucet.

The backflow preventer provided by MIOX Corporation is installed at the source of the water connection, and not on the MIOX unit. If it is installed on the MIOX unit, the check valve will be operating with the wrong orientation, and no water will flow to the MIOX unit. During operation, the backflow preventer will occasionally activate, which causes a small amount of water to be discharged. This is normal and does not indicate a need for service.

***II.5.1.D. Water from Softener to the MIOX Unit***

Glue the supplied PVC reducer bushings into the water softener adapter fitting. Place Spears blue 75 thread sealant on both ends of the gray plastic 3/4" nipple pipe (approximately 1 3/4" long) and then insert the pipe into one end of the tee. Insert the other end of the nipple pipe into the adapter fitting for the outlet connection, with the **outward-pointing arrow**. Coat the male end of the two metal 3/4" hose bibbs with Spears blue 75 thread sealant and place one hose bibb into each of the remaining two openings of the tee. Cut the 1/2" clear braided hose long enough to allow flexibility of movement for the softener and MIOX system. Attach a piece of hose to each hose bibb with the green plastic connectors, clamping each hose securely with the green plastic clamshell. Before connecting one of the hoses to the MIOX system, turn on the main water supply and flush water through the softener until the water is clean and clear.

***II.5.1.E. Brine Recharge Hose Connections***

The water softener uses fully saturated brine taken from the brine tank to recharge the softener. In order to connect the water softener recharge hose, use Spears blue 75 thread sealant to coat the **smaller** male threads (1/4") jutting off of the water softener head. Take the small black connector elbow and thread it onto the brine inlet. Then attach the 3/8" polyethylene tubing (with the gray check valve). Make sure that the arrow on the check valve is pointing from the brine tank **toward** the softener. Connect the other end to the 1/2" NPT female spin fitting on the side of the brine tank. This connection should be made before the brine tank is filled with water in order to avoid spilling any water.

***NOTE:* Incorrectly connecting the check valve will not allow the softener to regenerate itself and may cause the brine reservoir (tank) to overflow. Be sure the flow arrow on the check valve points in the direction of the water softener and away from the brine tank.**

***II.5.1.F. Water Softener Discharge Hose***

Connect the larger male threads jutting off the head of the water softener using Spears blue 75 thread sealant and connect the larger black elbow to the discharge threads. Insert the 1/2" discharge tube into the elbow, and place the other end into a drain.

> **⚠CAUTION** **Do not pipe the water softener discharge into the same drain header as the drain header for the brine and oxidant tank overflows. Install separate drain headers to a common floor drain. If all of the systems are tied in to the same drain header, high backpressure from the water softener discharge drain can backflow up the brine and oxidant tank overflow lines and fill the brine generator and oxidant tank with calcium rich brine. This will result in brine tank flooding, calcium carbonate contamination of the electrolytic cell, and dilution of the oxidant solution.**

### *II.5.1.G. Cold Weather Protection*

The water softener must be protected from freezing temperatures. If it is installed outside or in an area that is not heated, precautionary measures must be taken to prevent freeze damage to the unit. This can include installing a space heater, draining the softener or moving unused tanks to a warm storage.

## II.6. Oxidant Solution Tank Installation

The oxidant solution tank is designed to act as a holding tank for the disinfectant solution. The capacity of this tank is sized to accommodate peak demand requirements of the water system.

Figure 8 shows a typical drawing of a standard tank. A on-site oxidant solution tank installation kit is shipped inside the solution tank. Install the supplied warning labels on the outside walls of the oxidant tanks, following the provided guidelines and instructions.

**Figure 8. On-site Oxidant Solution Tank**

### II.6.1. Ventilation Requirements

**⚠WARNING Any process that involves electrolysis of water liberates hydrogen gas. The ventilation system in the oxidant tank is designed to remove hydrogen gas. The plumbing and ventilation requirements explained in this manual must be followed explicitly to ensure proper hydrogen venting and prevention of explosions or other hazardous situations.**

The MIOX solution tank must **ALWAYS** be vented to the atmosphere outside the facility to remove any possibility of hydrogen gas formation, which can be explosive if exposed to an ignition source. The PVC drop tube and the elbow assembly are shipped in the on-site oxidant solution tank kit. The proper diameter drop tube must be used for the size of the on-site generator feeding oxidant to the oxidant tank.

***NOTE:* All systems must have a properly installed Liquid Hydrogen Safety system to operate safely. See Appendix A for more details.**

As oxidant flows down the drop tube, hydrogen bubbles up through the oxidant solution and out the vent tube. This vent configuration is required in order to remove hydrogen before it enters the oxidant tank. The primary vent should **never** be directly from the side of the oxidant tank, such as the overflow port.

If the solution tank is not supplied by MIOX Corporation, a drop tube and vent must be fabricated. The user is responsible for purchasing sufficient 1" CPVC piping to attach to the top of the tee and vent to the atmosphere outside the building.

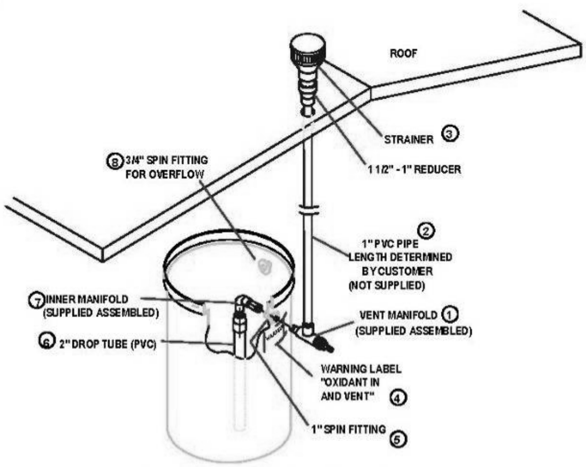



**Figure 9. Ventilation Requirements**

### II.6.2. Solution Tank Liquid Level Switch Installation

For MIOX-supplied on-site oxidant solution tanks, the liquid level switch is shipped loose in the tank. If the solution tank is not shipped with the SAL system, the level switch is shipped separately. The switch is designed to operate with the SAL system. To install the level switch in the tank, complete the following steps:

1. Coat the male end of the street elbow with Spears blue 75 thread sealant and then connect it inside the solution tank into the 1/2" spin fitting at the top of the tank.
2. Feed the electrical cord through the elbow and out of the tank.
3. Seal the male end of the liquid level switch with Spears blue 75 thread sealant and then screw it into the female end of the street elbow. Hand tighten.

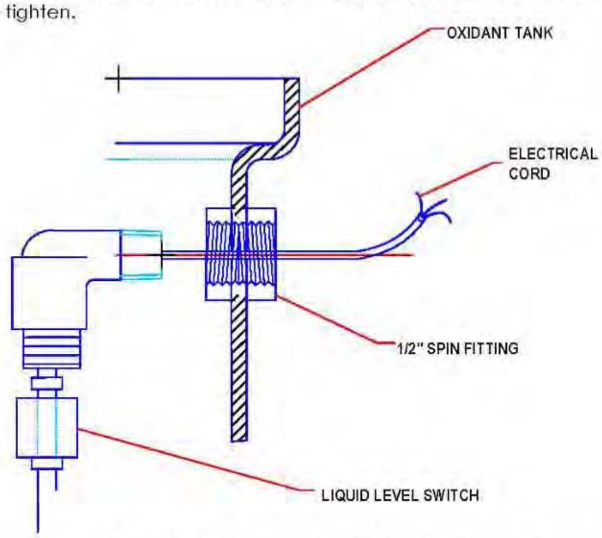



**Figure 10. Solution Tank Level Switch Installation**

The wire from the solution level switch is fed into the SAL unit through one of the four feedthrough fittings on bottom of the blue control cabinet. If all of the feedthroughs have wires in them, it is acceptable to combine the wire with another one. The terminals for the MIOX solution switch are shown in the electrical schematic that is attached to the inside door of the control panel.

***NOTE:*** **Take special care to ensure that the wires are connected properly. If two systems are linked, the wires must be connected as follows:**

| | Unit #1 | | Unit #2 |
|---|---|---|---|
| Black wire | Terminal #15 | jumper wire to | Terminal #15 |
| Red wire | Terminal #17 | jumper wire to | Terminal #17 |
| White wire | Terminal #18 | jumper wire to | Terminal #18 |

When more than one system is installed, a jumper cable (3 wires) must be placed between pin 18 on unit 1 and pin 18 on unit 2. Similarly in 17 on unit 1 must be jumpered to pin 17 on unit two and pin 15 on unit 1 to pin 15 on unit 2. After all wires have been fed through, be sure to tighten the feedthrough to prevent water damage.

#### II.6.3. Solution Tank Lid

The solution tank lid is meant to cover the tank during operation. The lid helps reduce volatilization and extends the life of the oxidant solution. Beware of the potential for hydrogen gas when removing the oxidant tank lid. Avoid all ignition sources in the vicinity of the oxidant tank.

#### II.6.4. Feed Line Connection

The valve at the bottom of the solution tank provides MIOX solution to the water system for purposes of disinfection. MIOX solution can be injected into the water system with a chemical feed pump or a venturi injector. The pump is typically mounted in a side stream of the main water line. The injection system is not a standard part of the SAL system installation due to variables with different water supply systems and should be designed by a qualified engineer, MIOX Corporation distributor, or salesperson.

#### II.6.5. Overflow Port

A 1" overflow port connection fitting has been provided at the top of the solution tank. This should be piped to a drain or other suitable discharge outlet with 1" schedule 80 CPVC pipe. Be certain to use a separate drain header for the oxidant tank and for the water softener discharge. Otherwise, high backpressure from the water softener discharge drain can create backflow up the brine and oxidant tank overflow lines, filling the brine generator and oxidant tank with calcium rich brine. If the customer elects not to run the overflow drain, then the 1" outlet must be plugged to prevent gasses in the storage tank from venting to the room.

## II.7. Water Heater or Water Chiller (optional)

Water heater and chillers are provided with the MIOX system, but may not be required by all users. A heater is necessary if the temperature of the feed water at any point during the year falls below 50 °F (10 °C). A chiller is necessary if the water temperature rises above 85 °F ( 29.4 °C) at any point during the season of system operation. Low temperatures must be avoided to protect the cell from deplating, while high temperatures must be avoided to protect components downstream from high cell discharge temperatures. Maintaining the water at the proper temperature will also assist in maintaining rated production of the on-site generator.

Chillers can be located inside or outside of the facility. Allow 3 feet (1 yard) of clearance in front of and behind the chiller for unrestricted air flow. See Manufacturer equipment manuals for details.

# III. Operations

**⚠CAUTION**

**⚠WARNING**

**SAFETY PRECAUTIONS AND WARNINGS**

- The on-site oxidant solution is a disinfectant—NOT DRINKING WATER—and therefore should NOT be consumed without diluting it with water. On-site oxidant solution is not a desalinization device for making fresh water from salt water, but instead uses salt water in making the on-site oxidant solution (a disinfecting solution).
- For water treatment, ensure the proper does of oxidant for the water to be treated. Consult a professional for proper dose rates.
- Do not add other chemicals to the brine or oxidant tanks.
- Any process that involves electrolysis of water liberates hydrogen gas. Hydrogen gas could cause an explosive situation if ignited in an oxygen atmosphere.
- Always assume hydrogen is in and around the oxidant tank.
- Ensure that NO flames or ignition sources are in or around the tank.

## III.1. System Description

The SAL system is designed for commercial operation on a wide variety of applications. The oxidant can be used for potable water, waste water, swimming pools, cooling towers, odor control, food processing, and any other applications where a strong chlorine-based oxidant is desired. Depending upon the size of the electrolytic cell, 2.5, 4, or 10 lbs of FAC is produced per day. The electrolytic cell is powered by a switching power supply operating with a conservative duty cycle. The controls and other devices are powered by a separate 24 VDC power supply. The system is controlled by a microprocessor-based controller that maintains a constant level of oxidant production under all conditions. The controller supports system diagnostics as well as alarms for interface to autodialers, SCADA systems, or any other type of alarm annunciation.

The SAL system is modular and includes a control panel, a mounting panel with brine filter, a brine pump, a plumbing manifold, and an electrolytic cell. The control panel is a stainless steel enclosure meeting U.S. and international electrical standards. All components external to the control panel are low voltage devices that are not inherently harmful to humans. A typical SAL system installation includes a water softener to remove calcium, as well as a brine generator and oxidant solution tank. Each SAL unit consists of three basic subsystems:

1) Fluid subsystem

2) Power subsystem
3) Controls subsystem.

#### III.1.1. Fluid Subsystem

The fluid subsystem provides water to the brine generator and water to the electrolytic cell. The water pressure and flow rate are regulated in the system to provide continuous, steady-state operation and stable oxidant production. Potable or clean source water is fed to the system from a suitable water source. Water flows to the brine generator where the liquid level in the brine generator is controlled with a float valve in a still well (4" PVC pipe). The water level is controlled by the float valve to ensure the brine pump head is always flooded. This precludes brine dry-out in the pump head.

During system operation, the electric solenoid valve opens and allows water to flow through a PRV through a heat exchanger in the control box to the cell. Water flowing through the heat exchanger provides cooling for the power supply—a much more effective cooling process than ambient air cooling. The PRV sets the downstream pressure at 15 psi (103 kPa) irrespective of the upstream pressure. With a steady pressure of 15 psi (103 kPa) in the cell, the flow rate is controlled by a manually adjustable flow control valve. In order to ensure the correct concentration of brine in the cell, a brine pump meters saturated brine from the brine generator to the feed line into the cell. The controller monitors amperage on the cell and controls the speed of the brine pump to maintain the proper concentration of brine in the cell so that the amperage in the cell is always at specified levels.

#### III.1.2. Power Subsystem

The SAL series systems have two power supplies. The main power supply converts 220 VAC single-phase power to 12 volts DC for energizing the cell. This is the only function of the large power supply. Depending upon the system, the cell operates from 840 – 2500 watts during normal operation. This switching power supply provides a clean source of power under a variety of loading conditions and power supply variations. The supply can operate from nominal 220 VAC and from 50 to 60 cycles.

The second power supply has an input voltage of 220 VAC and delivers 24 volts DC. This feeds power to the control board, the brine pump, and the solenoid valve.

Main power to the system is switched with a combination switch and circuit breaker. The switch is located on the lower left side of the control box. Power to the system is fed from a standard NEMA 6L-30 male plug on a 10-foot power cord.

The SAL-30 and SAL-40 systems can also be configured for 110 VAC single phase power with a 30A service circuit.

#### III.1.3. Controls Subsystem

The SAL system is a fully automated system that provides a steady and consistent production of on-site oxidants under all normal conditions. An on-board controller mounted on the master control unit (MCU) board monitors the amperage to the cell. The operational range is from 70A ± 10% for SAL-30, 90A ± 10% for SAL-40 and180A ± 10% for SAL-80. If the amperage falls below the minimum amps, the controller sends a higher signal voltage (0 to 5 VDC range) to the brine pump to tell it to run faster. At faster speeds, the brine concentration increases, which causes the conductivity and amperage to climb. If the amperage gets above 190 amps, the brine pump will slow down. Because amperage applied is equal to chlorine produced, the amount of chlorine production is always reasonably steady.

***NOTE:* The three momentary buttons that provide input to the controller must be pressed and held to initiate their function.** The red mushroom button when pushed in will put the system into a Standby condition. Turning the red mushroom button clockwise a little will allow the button to pop back out and allow the unit to re-start.

The controller also detects upset conditions. If the salt is low in the brine tank, the brine pump will continue to increase its speed to try and produce oxidant. If the maximum brine pump speed is exceeded, the system will fault and display a low brine condition related fault. Likewise, if water flow is restricted, the brine pump will begin to slow down to reduce the brine concentration. If the brine pump voltage drops too low, the system will fault and display a low water condition. The pipe manifold also includes a low pressure water switch. If the water pressure falls below 20 psi (138 kPa), the system will fault. If the system goes to a fault mode, it will change the state of the contact switch that is wired to an external connector. The alarm relay can be wired to a phone dialer, SCADA system, alarm lights, or other annunciation device. See section11.3.4 for directions on how to properly wire the alarm relay.

There are three momentary buttons and one red mushroom switch on the touch screen controller display that provide input to the controller. The buttons must be pressed and held to initiate their function. Four status lights across the top of the display panel provide the operating status of each unit. The display panel lists cell amperage and pump voltage, as well as any fault conditions or standby messages, and can also display cell voltage and unit hours. See **Error! Reference source not found.** for an example of the controller display panel. The system electronic controls are designed to diagnose and adjust the unit to optimum operating conditions or shut down the system should a fault occur.

#### *III.1.3.A. System Operations Controls*

The control panel has the following easy-to-read system operation controls:

**Standby Switch**
Also known as Master On Switch. The Standby switch is a red mushroom knob that puts the system into or out of standby (standby – in, operate - out), as long as certain operating conditions are met. (For example, when the solution tank is full, the system will remain in standby.) The display panel

will indicate why the system is in standby. To restart the unit from Master off, rotate the red knob clockwise.

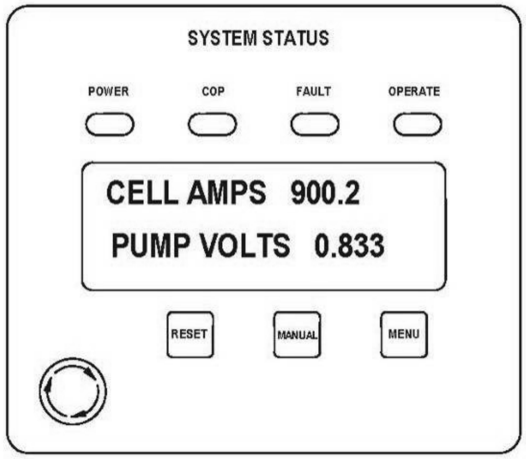



**Figure 11. Example System Display**

**Reset Button**
The reset button restarts the system from a fault condition.
-In diagnostic mode, the reset button decrements various functions (ex. clock).
-In operate mode, the reset button will decrease the brine pump voltage when pressed.

**Manual Operation Button**
In diagnostic mode, the manual operation button performs the following functions:
-It enters a test module to begin that module's diagnostic test series.
-It turns the output test item off and on.
-It increments various functions (for example, the clock).
In operate mode, the manual button will raise the brine pump voltage when pressed.
The manual operation button can also be used to bypass the cell purge sequence when system enters standby
*Do not bypass purge on a routine shutdown. This feature should only be used for quick maintenance and service checks when the system will be turned on again right away.* The manual button will also start the unit when the oxidant tank is between low and high setpoints, the area called Tank OK.

**Menu Button**

The menu button is used to enter diagnostics mode while the system is in stand-by.

-In diagnostics mode, it skips to the next test module or to the next diagnostic test within the test module

##### III.1.3.B. *System Status Lights*

The system status lights across the top of the control panel display include:

**POWER**
When the POWER light (green) is lit, the power is on.

**COP (COMPUTER OPERATING PROPERLY)** **180.2**
When the COP light (green) is lit, the automated control panel is operating properly.

**OPERATE**
When the OPERATE light (green) is lit, the amperage to the cell is in the optimum operating range for the MIOX system. If this light is off, the system is either in standby mode with "Standby" and the reason for standby displayed on the screen, an alarm condition with the alarm reason displayed, or it is adjusting to optimum operating conditions:

SAL-30: 70 ± 10%
SAL-40: 90 ± 10%
SAL-80: 180 ± 10%

The OPERATE light is only lit when the cell is in a running state and in the parameters shown above.

**FAULT**
When the FAULT light (red) is lit, the system is shut down due to fault condition. The specific fault will be displayed after the purge sequence is complete.

##### III.1.3.C. *Fault Conditions*

When the fault light on the display panel is red, the system is in alarm mode. Hard faults require manual operator intervention. If the system is found in a hard fault condition, the operator must push the system RESET button in order to restart the system. Diagnostic fault information on the display will be lost once the system is restarted, so be sure to record the data first. Refer to Table 1 for a listing of the faults for the SAL system. Refer to the Troubleshooting section for possible causes and solutions.

> ***NOTE:* Be sure to record the data from the diagnostic fault display panel before the system is restarted to avoid losing the information.**

When a hard fault condition is initially discovered, the controller will check the condition 10 times, while the display reads **WARNING**, followed by a description of the fault. If the problem has not corrected itself after 10 control

loop passes (about 10 seconds), the system will hard fault. After 3 minutes, the system will attempt to restart. If the fault condition still exists, it will check it 10 times before hard faulting again. The system will attempt to restart itself a total of 3 times, after which it remains in hard fault until the problem is resolved. The only hard fault that will shut down the system immediately is "VHI CELL CURRENT," or Very High Cell Current. The external alarm relay and Fault LED will be active with all hard fault conditions.

**Table 1. Alarm Description**

| ALARM DESCRIPTION | SOFT | HARD | ALARM | RESTART 3X |
|---|---|---|---|---|
| SOFT FAULTS | | | | |
| Master Off (Red Mushroom) | X | | | |
| MIOX Tank OK | X | | | |
| MIOX Tank Full | X | | | |
| Bad Float | X | | X | |
| Bad 5V Supply | X | | X | |
| Bad 24V Supply | X | | X | |
| Power Loss (Screen Blank) | X | | X | |
| HARD FAULTS | | | | |
| Hi Oxidant Temperature | | X | X | X |
| Hi Cell Current | | X | X | X |
| Low Cell Voltage | | X | X | X |
| Low Cell Current | | X | X | X |
| VHI Cell Current | | X | X | No Restart |
| Low Pump Voltage | | X | X | X |
| Low H2O Pressure | | X | X | |
| Power SSR Failure | | X | X | Note 1 |

Note 1: SSR (Solid State Relay) failure mode is usually a shorted SSR. Power supply may stay energized. Water solenoid valve will cycle one second on and one second off and brine pump will stop. This operation is to protect the cell and its plumbing from high temperatures. Cell may try to boil dry. Oxidant tank dilution will occur. Water flow to oxidant tank will continue until manually reset.

### *III.1.3.D. Alarm Relay External Controls*

MIOX systems come with an external an alarm relay. The three-pin male connector on the left side of the control cabinet is the external Alarm Relay

connector. This output supports a single Form C relay with 7A contacts at 240 VAC and a ½ horsepower rating, or 120 VAC and a ¾ horsepower rating. This output may control pumps, valves, phone dialers, radio, etc., and is deactivated during any indicated faults that shut the system down. The alarm function will try to reset and restart the system 3 times. If all 3 restarts fail to get the system into a proper operating condition, then the system will stay faulted. Approximately 3 minutes will pass on each fault before the system will try to restart. Any time the system is in an alarmed fault state, the Alarm Relay output is de-active. Loss of main power causes an alarm condition.

#### *III.1.3.E. Remote Communications*

All of the SAL series product line supports external communications for remote display, datalogger download, and remote control. The onboard controller supports RS232 output via a serial port on the MIOX controller board. This output, with a modem or other interface (i.e. RS485, RS422, terminal emulation software, etc.), may support numerous SCADA and other remote communication formats. Contact your distributor or MIOX customer service for details.

#### *III.1.3.F. Datalogging*

All of the SAL series product line supports datalogging capability. Over 10,000 floating point samples can be stored at any one time. The storage is in EEPROM, which can be written over 100,000 times and the data may be downloaded by remote communications at any time via serial port. To use the datalogger capability, the user must have access to a terminal emulation software package and the system must be in standby while the datalogger is downloading. The controller cannot record and play back data at the same time. Contact your distributor or MIOX customer service for details.

## III.2. Initial System Settings and Start-Up

This chapter details the initial system settings and the steps for initial system start-up.

### III.2.1. Ensure that Installation is complete

### III.2.2. Electrical Check

Verify that the correct AC power is being used, nominal 220 VAC, single-phase, 50 to 60 hertz. The SAL-30 and SAL-40 may also use 110 VAC single phase power.

### III.2.3. Loading the Salt into the Brine Generator

Salt of the necessary purity is loaded into the brine generator. Make-up water flows through a float valve inside the 4" PVC standpipe in the brine tank. Water flows out the bottom of the pipe and through the salt, where it is converted to fully saturated brine, and then through the brine filter and brine pump on the SAL system mounting plate.

#### *III.2.3.A. Minimum Salt Specifications*

The MIOX system operates using sodium chloride salt. MIOX Corporation highly recommends 99.5% purity salt without additives or preservatives. Ensure that the concentrations of calcium (Ca) be less than or equal to 0.03%, that the magnesium (Mg) concentration be less than or equal to 0.02%, and that the manganese (Mn) be less than or equal to 0.005%. Course or extra course solar salt and palletized salt may meet these requirements. Evaporated (food quality) salt may meet these requirements as well, but a quartz bed must be installed (see the next section). Rock salt is unacceptable and will rapidly contaminate the system.

> ***NOTE:*** **Rock salt is unacceptable for use with MIOX cells. The contaminants in this salt will rapidly contaminate the system.**

Surfactants (detergents) are typically added to salt pellets in order to help clean the ion exchange resin in water softeners when the water softener is in the regeneration cycle. Salt with surfactants is not harmful to on-site generators, but is **not** recommended because the surfactants will create foam in the oxidant transfer and hydrogen vent piping.

While additives in general are not recommended for on-site generators, there is nothing inherently wrong with some additives including iron removal agents present in the salt. Anti-caking agents are an acceptable additive for salt used in on-site generation and may even help the salt from binding or bridging in the brine generator. Citric acid based cleansers are sometimes used to help clean resin in ion exchange water softeners. As long as these cleansers do not have surfactants, they may be permissible. Experience will determine whether their use is acceptable.

**⚠WARNING Do NOT use salt that contains surfactants. These agents could create foam that could block the hydrogen venting system.**

***III.2.3.B. Quartz Bed Installation (Optional)***

Quartz bed installation is required when finely grained, granular salt is used. This includes food grade salt. Fine-grained salt particles can clog the 5-micron pleated filter cartridge installed downstream from the brine tank discharge quickly. To avoid this, a two-layer washed quartz rock bed must be placed in the bottom of the tank. The bottom layer should be approximately 7 inches (18 cm) of quartz rock between ¼ and ½ inch (0.5 - 1.3 cm) in size. The top layer should be approximately 5 inches (13 cm) of quartz rock between 1/8 and ¼ inch (0.3 - 0.5 cm) in size.

***NOTE:*** **Quartz rock is required for this application due to its strength. Other materials, such as gravel will not withstand the grinding caused by salt entering the tank and will quickly form and insoluble slurry.**

***III.2.3.C. Initial Salt Filling***

1. **Close Outlet Valve –** Make sure the brine tank drain valve is in the closed position.
2. **Disconnect and flush the water line at the MIOX Panel Connection**
3. ***Tighten all the Hydraulic Connections*** **–** ensure that all hose fittings are tightened
4. **Add Salt –** Pour salt into the brine tank until it is full. You can fill salt all the way to the top.
5. **Fill Tank with Softened Water –** Open water supply valve. The system has a float that will control the water level in the tank. Do not start the system until the appropriate water level has been reached, causing the float to cut off flow to the tank.
6. **Allow Salt to Dissolve –** After filling the brine tank with salt and softened water, allow 30 minutes for the salt to dissolve before priming the brine system.

**III.2.4. Checks Prior to Start-Up**

After the system has been installed by a trained technician and before turning it on, the following items should be checked:

1. Hose fittings tightened
2. Electrical connections to cell electrodes good (75 inch-lbs. torque)
3. Electrical power connection good (cord plugged in)
4. Electrical control box securely closed
5. Water valves open
6. Brine tank drain valve in **closed position**
7. Brine tank full of salt

8. Water softener connected and operating properly

#### III.2.5. Brine Pump Priming

1. Open the outlet valve on the discharge of brine tank.
2. Pump the primer bulb until it is hard.
3. Push the pressure relief button on top of the of brine filter. Air will be evacuated. Continue to press until primer bulb is soft.
4. Repeat steps 2 & 3 repeatedly until the filter housing is full of liquid brine and the pressure relief button is evacuating liquid.
5. Clean up any spilled liquid to prevent corrosion.
6. The brine system is now primed and the system is ready for operation.

The water level in the brine generator is designed to maintain water level above the pump heads in order to ensure that the pump heads never dry out. Dried out pump heads can cause salt build-up in the brine pump gears and lead to pump failure.

### III.3. Routine Operations

#### III.3.1. Turn on Breaker/disconnect

The breaker is located under the control box and the control box is located in the bottom lower left of the control panel. Once the breaker is switched, the display and system will power up.

#### III.3.2. Rotate Red Mushroom Switch

Once the red mushroom switch is rotated clockwise, the switch will pop out. The system monitors the oxidant level switch. If the oxidant tank is empty, the system will attempt to initiate the start-up sequence and then start to operate.

#### III.3.3. Operating Window

Ensure the system is in the operational window by verifying that the operate LED comes on.

The SAL series automatic control system is designed to measure the concentration of the brine at the cell. The electrolytic cell receives a 12 VDC potential.

This voltage enables the cell to reach the optimum current operating range. These voltage and current readings will scroll through the 2 x 16 line display. The measured amperage should fall within the following guidelines:

| SAL-30: | SAL-40: | SAL-80: |
|---|---|---|
| 70 ± 10% | 90 ± 10% | 180 A ± 10% |

During normal operation, the amperage will fluctuate between the high and low values shown in the chart above. The brine pump may also step up or

down, but the pump control voltage, indicated on the display, should be between 0 and 5 VDC.

### III.3.4. Start-Up Sequence

The MIOX system goes through a start-up sequence that includes cell charged with water and brine pump activation.

The following information is displayed when power is fed to the controller:

MIOX CORPORATION
<Date software programmed; Software version>
<Month and Year of chip programming; System software; Chip original date, month/year>

*At this point the controller tests the alarm and operation lights by having the alarm beep and all LEDs light
<Day of the Week>
<Date>
<Unit Hours>

The automatic controller varies the amperage by changing the variable brine pump potential in the range from 0 to 5 volts. If the brine concentration is too high, the brine flow rate is reduced by slowing down the pump; conversely, too low a concentration is corrected by speeding up the pump. The cell amperage will increase until it stabilizes in the optimal operating range. At this point, the unit is producing the on-site oxidant disinfecting solution.

When the operating window is reached, the MIOX cell will begin to produce oxidants and fill the solution tank. When the solution tank is filled to the high level, the level sensor puts the system into a standby mode. When the solution tank is drained of MIOX solution below the bottom level sensor, the system will automatically restart and run until the solution tank is filled to the preset high level.

**⚠WARNING The on-site oxidants collected should be used as quickly as possible in treating raw water to gain the maximum benefit of their disinfectant power. If the MIOX solution is stored for more than 30 minutes before use, it should be stored in a covered container. Containers for storage should be plastic (HDPE), well sealed, and properly vented. MIOX solution that has been properly stored for up to 5 days can be used for disinfection.**

When the system goes into standby mode because the oxidant tank high level switch is activated, the SAL system controller goes through a purge sequence to remove brine from the lines and cell. Brine in the cell can cause an adverse battery effect that can shorten the life of the cell. During the shutdown sequence, the brine pump and cell power are turned off, but the water solenoid valve stays on for a few seconds before it is finally turned off.

During start-up from the standby mode, the system also goes through a charge and startup sequence. When the low level switch in the oxidant tank is activated, the solenoid opens to allow water flow. After a few seconds the brine pump comes on at the same speed that it was running when it went into standby. After a few more seconds, cell power is applied. At that point, the system should come into the amperage "operate" window within a minute or two.

**⚠WARNING** **If you have excessive stops and starts, the on-site oxidants will be diluted with start-up changes and shutdown flushes. This can be corrected by installing a longer float level sensor.**

**III.3.5. Water Softener Operation**

Ensure that the water softener is operating properly before initial startup. This can be done by testing the water flow from the water softener for hardness with a hardness test kit or strip. (Test strips are included with the Kinetico® water softener owner's manual.) If hardness is more than 1 grain (17.1 ppm), the softener is not functioning properly. Verify the following:

1. **Feed Supply Water:**

**The feed supply water must be connected to the proper inlet on the water softener head, with the inward-pointing arrow (**

Figure 7*)*. Water from the softener to the SAL system must be connected to the outlet, with the outward-pointing arrow.

2. **Check Valve:**
The brine recharge hose has a check valve in the middle of the line with an arrow that must be pointing from the MIOX brine tank toward the water softener.

3. **Brine Tank:**
Verify that there is sufficient brine in the MIOX brine tank for the water softener to regenerate. Confirm that brine flows freely out of the tank.

***III.3.5.A. Regeneration Cycle***

The softener operates "on demand" based on your actual water usage. It is not necessary to set any timers since the regeneration cycle is automatic.

During regeneration, water flows up through the media bed as opposed to the downward flow during service. The regeneration process for both tanks consists of three steps: *Brine, Rinse*, and *Backwash*. The control disc on top of the softener moves in a clockwise direction, with the dot indicating the following steps:

- **Dot at 6:00 position:**
  1. Main Tank is in service; Remote Tank on hold.
- **Dot between 6:00 and 12:00 positions:**
  2. Main Tank regenerating (Brine/Rinse); Remote Tank in service.

3. Main Tank regenerating (Backwash); Remote Tank in service.
- **Dot at 12:00 position:**
  4. Main Tank on hold; Remote Tank in service.
- **Dot between 12:00 and 6:00 positions:**
  5. Main Tank in service; Remote Tank regenerating (Brine/Rinse).
  6. Main Tank in service; Remote Tank regenerating (Backwash).

After Step #6, the process begins again with Step #1.

#### *III.3.5.B. Manual Regeneration*

If the brine tank should run out of salt for any reason, you will have to manually regenerate the unit. To do this, you must first add salt and then wait a minimum of 30 minutes for it to dissolve. Next, using a Phillips-head screwdriver, push down on the actuator in the center of the clear cap on top of the control valve and hold down while turning the screwdriver clockwise until you hear three or four clicks and water begins flowing through the drain line. After the water flow stops, (which will be 29 to 90 minutes, depending on the model), repeat the manual procedure to be sure both resin tanks are regenerated.

### III.3.6. Water Softener Specifications

**Table 2. Water Softener Specifications**

| | Model CC208 | Model CP208 | Model CP210 |
|---|---|---|---|
| **Maximum Compensated Hardness (gpg)[1]** | 42 | 80 | 100 |
| **Service Flow Rate (gpm)[2]** | | 5 | |
| **Backwash Flow (gpm)[3]** | 1.4 | 2 | 3 |
| **Regeneration volume (gal)** | 14 | 35 | 102 |
| **Resin per Tank, cu. ft.** | 0.4 | 0.7 | 1.5 |
| **Tank Freeboard (inches)** | none | 15 | 18 |
| **Capacity per Cycle, grains per cubic foot** | 30,000 | 17,500 | 37,270 |
| **Grains Exchange per Lb. of Salt** | 3,500 | 3,181 | 3,727 |
| **Salt Used per Cycle (lbs.)** | 1.6 | 5.5 | 10 |
| **Regeneration Time (min.)** | 11 | 45 | 90 |
| **Water Used per cycle (gals.)** | 77 | 148 | 180 |
| **Min./Max. Operating Pressure** | | 103.4 - 861.9 KPa (15 - 125 psi) | |
| **Min./Max. Operating Temp.** | | 2° - 49 °C (35° - 120 °F) | |

[1]Maximum compensated hardness with #4 Meter Disc in grains per gallon.
Compensated Hardness = [3 x (ppm of ferrous Fe and Mn)] + grains per gallon hardness.
17.1 ppm = 1 grain = 17.1 mg/L.
[2]Service Flow Rate is rated at a 15 psi pressure drop. Rate is for a low flow nozzle.
[3]50% Expansion.
SODIUM INFORMATION: Water conditioners using sodium chloride for regeneration add sodium to the water. People who are on sodium-restricted diets should consider the added sodium as part of their overall sodium intake.

### III.3.7. Diagnostics

Diagnostic mode can only be started from standby by pressing and holding the MENU button. (From operation mode, enter standby mode by pushing in the mushroom button. You can bypass the purge by pressing and holding the MANUAL button.) The diagnostic program begins by testing the function of each button on the display panel (MENU, MANUAL, and RESET).

The first prompt is "Push MENU Switch." After you push the MENU switch, the display will indicate "MENU SWITCH GOOD." This is followed by "Push MANUAL Swt," "MANUAL SWT GOOD," "Push RESET Swt," and "RESET SWT GOOD." If a switch is not functioning correctly, the program will not continue.

During the rest of the diagnostic sequence, pressing MANUAL will enter the test module indicated and pressing MENU will skip that test module. Within each test module, pressing MANUAL will turn the output item being tested off and on, and pressing MENU will skip to the next function. Pressing MANUAL will also increment the function where appropriate (ex. clock), and pressing RESET will decrement the function where appropriate. *You must press and hold the button to initiate the function.*

### III.3.8. Testing Outputs

*Press MANUAL to enter the test module and to turn each test item off and on; press MENU to skip the test module; A function must be turned off before skipping to the next.*

- **TEST H20 VALVE/H2O VALVE IS OFF**
  Pushing MANUAL will turn on the water solenoid valve; pushing MANUAL again will turn it off.
- **TESTING ALARM/ALARM IS OFF**
  Pushing MANUAL will turn on the alarm relay; pushing MANUAL again will turn it off.
- **TESTING PWR ENBL/PWR ENBL IS OFF**
  Pushing MANUAL will turn on the main volt power supply; pushing MANUAL again will turn it off. PWR ENBL is electrically interlocked with the red mushroom switch. The red mushroom switch must be up for the enable to work.

### III.3.9. Testing Inputs

*Press MANUAL to enter the test module; press MENU to skip the test module and to skip from one input test to the next; Must test manually by manipulating the physical item off and on; 0 = closed (on), 1 = open (off)*

- **MASTER ON SWT 1**
  Releasing the red mushroom button should toggle to a "0"; pushing the red mushroom button down should toggle back to a "1"
- **H2O PRESSURE 0 or 1**

Closing the water supply value and relieving water pressure at the pressure switch should indicate 0. Restoring pressure should indicate 1.

- **LOW FLOAT 0 or 1**
  Indicates "0" if bottom level float in oxidant tank is down; indicates "1" if float is up
- **HI FLOAT 0 or 1**
  Indicates "0" if top level float in oxidant tank is down; indicates "1" if float is up

**III.3.10. Testing Analogs**

*Press MANUAL to enter the test module; press MENU to skip the test module <u>and</u> to skip from one analog test to the next; Cannot turn analogs off and on; simply reads the value being measured*

- **CELL AMPS**
  Should be < 10, since unit is not operating
- **CELL VOLTS**
  Should be < 2, since unit is not operating
- **PUMP VOLTS**
  Will read between 0.110 and .130, since the pump volts cannot be set to zero
- **5.00VDC**
  Tests 5V power supply; should read >4.5 and <5.5; < 4.50 goes to standby
- **CELL TMP IN (inlet water temperature)**
  Tests inlet water temperature; should read >42°F ; otherwise goes to hard fault

**24.00VDC**
Tests 24V power supply; should read >22.00 and <26.0; < 22.00 goes to standby, soft fault.

- **CELL TMP EX (outlet oxidant temperature)**
  Tests outlet oxidant temperature; should read <135°F; otherwise system goes into current foldback mode and gives warnings. If Outlet Temp exceeds 150°F, system will hard fault.

**III.3.11. RT Clock Setup**

*Real Time Clock is in a 24-hr. format; pressing MANUAL enters the test module and then indicates "The RTC is on"; MENU skips test module <u>and</u> skips to next function within this module; MANUAL increments the number; RESET decrements the number*

- Set Minutes
- Set Hours (use military time (24 hr. clock))
- Set Day of Week (cannot be decremented)
- Set Day of Month
- Set Month
- Set Year (Year Compliant; when moving forward, goes from 99 to 0; when moving backward, goes from 0 to 99)

- *After you have finished, the display will show the day, date, and time you have selected.*

**III.3.12. Unit Hours**

*Press MANUAL and RESET simultaneously and hold to set the run-time clock to zero hours; press and hold MENU to skip module*

Indicates number of hours on the cell to the tenth of an hour.
This function is only to be used when installing a new cell.

**III.3.13. Datalogger Information**

*Press and hold MENU to skip.*
This is the address and chip information for the datalogger. The starting point is shown as 39 0 when datalogger is zeroed.

**III.3.14. Thermal Reading Format**

Following the datalogger information, the 2x16 display states which mode for of thermal information is displayed (°F/°C). Press MENU when the format of choice is seen and that format will be stored in the controller memory, and then re-boot.

Upon rebooting, the display will read "MIOX Corporation" on the first line and the unit model on the second line. The system will then automatically restart, by beginning to operate or entering standby, depending on its previous status. (To resume operation from a standby mode, turn and release the mushroom button.)

# IV. Maintenance

**⚠CAUTION** **SAFETY PRECAUTIONS AND WARNINGS** **⚠WARNING**

- Disconnect power before working on units.
- Do not defeat or tamper with electrical interlocks or lockout mechanisms.
- Any process that involves electrolysis of water liberates hydrogen gas. Hydrogen gas could cause an explosive situation if ignited in an oxygen atmosphere. Proper venting of the oxidant tank is **mandatory**.
- Always assume hydrogen is in and around the oxidant tank. Remove the oxidant tank lid and vent the tank at least one hour prior to tank maintenance. Ensure that the facility is adequately ventilated.
- NO flames or ignition sources in or around the oxidant tank.
- Use confined space procedures prior to entry to the oxidant tank.
- Do not add other chemicals to the oxidant tank.
- Always follow the plumbing and venting procedures recommended by MIOX Corporation. Consult MIOX Corporation or an engineering professional prior to making changes to piping in oxidant tanks

## IV.1. General Periodic Maintenance

The MIOX system should be monitored periodically to ensure that the unit is running properly. MIOX recommends daily, weekly, monthly, and quarterly check. In order to maintain a history of system performance and assist in troubleshooting and warranty work, a suggested log is shown in Figure 12. It is recommended that this log be kept near the MIOX system for easy record keeping.

### IV.1.1. Daily Maintenance

**Check the Salt Level –** There must always be ample salt in the brine tank for MIOX system use, as well as water softener regeneration. MIOX recommends keeping a minimum of 1 foot (0.3 meters) of salt in the tank at all times.

**Record Operation Parameters –** the MIOX System Log Sheet that is provided *(Figure 12)* records the date, name of operator, appropriate water system parameters, hours on the SAL system, cell voltage (C1), amperage (A), pump voltage (P1), and pounds of salt added, if any. Since both operating hours and brine pump voltage (P1) are displayed on the bottom right of the screen, the user will have to toggle the menu button to change display screens.

> **⚠CAUTION** During the first few weeks of operation, it is critical to check the SAL system more frequently to identify and solve site-specific problems, fine tune the injection rate, and tighten any connections that may have loosened during shipping.

### IV.1.2. Weekly Maintenance

**Check Feed Water Pressure ( 25 psi - 100 psi; 172 kPa – 689 kPa) –** The feed water pressure of some water systems tends to fluctuate. If water pressure goes below 25 psi (172 kPa) or above 100 psi (689 kPa), it could damage the MIOX system. To protect against low water pressure, a low pressure cutoff switch is included in the piping manifold to put the system in standby if the water pressure drops below 20 psi (138 kPa). If pressure is restored, the system will restart automatically. If pressure-related faults are encountered, measures must be taken by the water system to adjust the feed water pressure. For instance, if feed water pressure is greater than 100 psi (689 kPa), a pressure regulator can be added to lower the pressure to a range of 50-70 psi (345 – 383 kPa).

**Check for Leaks –** Ensure that hoses and fittings are tight and leak-free. Any leaks found can usually be corrected with Spears blue 75 thread sealant. Do not put paste near the brine pump or water softener.

If the cell perimeter is seeping, tighten all perimeter bolts to 50 inch-lbs.

Check the brine pump fittings regularly for seepage and check the connections to verify that there is no salt around the flange sealing area

**Check for Loose Connections/Corrosion –** Check cell leads and lugs for corrosion. For light corrosion, clean cell leads and lugs with sandpaper or a wire brush. If severe corrosion is present, replace the cell lead. Tighten all connections to 75 inch-lbs. torque.

Check the cell lead connections at the power supply inside the control box. Make sure connections are tight and corrosion-free. For light or severe corrosion, repeat the steps above accordingly. Again, tighten the connection to 75 inch-lbs. torque, if necessary.

## MIOX System Log Sheet

MIOX System Serial Number: ______________________ MIOX Cell Serial Number: ______________________

| Date | Operator | Water Meter Reading (# of gals) | Water Produced Since Last Reading | System FAC Measured at | MIOX System Hours | Volts (C1) | Amps (A) | Pump Volts (P1) | Pounds Salt Added | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
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Figure 12. MIOX System Log Sheet

Notes/Comments: ______________________

**Check Buss Bar Connections –** Cell electrical connections will always be warm to the touch, but should never be hot (>85 °F; 29 °C). Heating increases exponentially as a function of resistance: a better connection provides less resistance, and thus, less heating. If a temperature gauge is not available, the user should be able to keep his hands on the cell connections for an extended period of time. Shock hazard is low since the cell operates at 12 VDC. If the cell connections are running hot, immediately shut down the system *(Section 10.9)*.

With the system off, first remove the cell lead to the cell to verify a good connection and no corrosion. If the cell lead is fine, then remove the flange nuts and the buss bar and check for signs of corrosion on the flange nuts, as well as both sides of the buss bar. Corrosion on the buss bar can easily be removed with emery cloth or fine sandpaper. Corroded flange nuts can be cleaned or replaced. **Be certain to check inner flange nuts and tighten, if necessary.** Do not apply significant torque to the inner flange nuts. Their only function is to compress an O-ring in the cell housing. Additional torque beyond that required (less than 5 inch-lbs.) to compress the O-ring could damage the electrode plate, or snap the stud off of the electrode plate, which would require cell replacement.

***NOTE:*** **Electrical grease or petroleum jelly can be used externally to help prevent corrosion on contacts. Contact interfaces need to stay dry and clean.**

Reassemble the buss bar, outer flange nuts, and the cell leads, and tighten the outer flange nuts to 75 inch-lbs. torque.

***NOTE:*** **Nuts holding the cell lead onto the buss bar and the buss bar onto the stud may loosen during the first few weeks of operation. Be certain to check and tighten these more frequently after initial startup.**

**Check Chlorine (FAC) Production –** Check and note chlorine production on the MIOX System Log Sheet (Figure 12) to identify trends over time.

**Check Water Softener (< 1 grain) –** Test water flow from the water softener with a hardness test kit to ensure that the softener is functioning properly. Water should be less than 1 grain (17.1 mg/l) hardness.

### IV.1.3. Monthly Maintenance

**Check Power –** Verify that AC voltage is correct. The SAL systems utilize 220 VAC +/-10%,, single phase power.

**Toggle Day Tank Float** Switch **–** The system is in standby when both floats are up. At this point, manually push both floats down to verify that the system operates. Floats should move smoothly approximately 1/2" in either direction. When both floats are pushed down, on-site oxidant production should begin.

**Check Flows –** Test flows separately from the anode and the cathode by measuring how much of a container is filled within a specified time period. Flows from

the SAL-80 should be approximately 10 gph from the anode and 5 gph from the cathode. If flow varies ± 2 gph from the values stated above, adjust the flow using the flow control valve. The flows from the SAL-30 should be approximately 5 gph and 2.5 gph and those from the SAL-40 about 8 gph and 4 gph. If in standby, push the manual mode button, and then let the system operate for 1 minute and check the flows again. Repeat this procedure until flows are within range.

### IV.1.4. Quarterly Maintenance

**Clean Brine Tank and Solution Tank –** Using a wet rag, wipe down the interior of the brine tank to remove any dirt or buildup. It is a good idea to completely drain and clean the brine tank every year to remove build-up that can be up to several inches thick. It is also a good idea to drain and clean the solution tank annually to remove particulates. Avoid any ignition sources in the vicinity of the oxidant tank.

**Clean or Replace the Brine Filter and Water Filter –** The brine and water filters are the same 5-micron 10 inch standard type unit for removal of particulate matter. The brine filter is located next to the brine pump on the lower left side of the unit and the water filter is located prior to the water softener or unit. The system should be off or in standby mode when filters are removed or replaced. Visually inspect the filter for clogging and debris. If flow is restricted, the filter should be replaced. Reinstall the filter. Discard the old filters according to local environmental codes.

***NOTE:* When replacing the brine filter, do not splash the brine pump.**

**Check Control Box Wiring Connections –** Electrical heating and cooling cycles may loosen connections. After turning the system power off, check all connections for tightness by gently tugging on them. Tighten down any loose screws or bolts. Wires should be clean, dry, and corrosion-free.

# System Checklist

| | Daily | Weekly | Monthly | Quarterly |
|---|---|---|---|---|
| Check Salt Level (Fill to top of tank) | √ | | | |
| Record Operation Parameters (See log sheet) | √ | | | |
| Check Feed Water Pressure | | √ | | |
| Check for Leaks (Hoses, tank, cell, etc.) | | √ | | |
| Check for Loose Connections/Corrosion | | √ | | |
| Check Buss Bar Connections (Warm to touch) | | √ | | |
| Check Water Softener (< 1 grain hardness) | | √ | | |
| Check Chlorine Production (See Section 10.6 in manual) | | √ | | |
| Check Power (220 or 110 VAC) | | | √ | |
| Check Flows | | | √ | |
| Clean Brine Tank and Solution Tank | | | | √ |
| Clean or Replace the Brine and Water Filter | | | | √ |
| Check Control Box Wiring Connections | | | | √ |

Figure 13. MIOX System Checklist

### IV.1.5. Electrolytic Cell Replacement

Generally, the cell will have a production life of several thousand hours. However, the life of the cell is affected by salt and water quality, water hardness, pH, and alkalinity. It is essential that ≥ 99.5% pure salt is used, with concentrations of Ca ≤ 0.03%, Mg ≤ 0.02%, and Mn ≤ 0.005%. If the following four conditions exist simultaneously, a replacement cell may be required:

a) The cell amperage is in the required window _and_
b) The flow through the cell is normal ***BUT***

c) Chlorine production is significantly below level shown in, *and*
d) Salt consumption is increased.

Returning the old cell

- Contact MIOX Corporation Customer Service to obtain a return merchandise authorization (RMA) number
- Pack cell in original packing materials or an appropriate substitute to prevent damage during shipping.
- Note the installation site name, system serial number, and number of hours the cell has been used. Enclose this information with the cell.
- Send the package freight prepaid to:

MIOX Corporation
ATTN: Customer Service
5601 Balloon Fiesta Parkway NE
Albuquerque, NM 87113

Please see Appendix D for more details concerning cell installation and replacement or call your MIOX distributor for questions regarding service or cell replacement.

## IV.2. Storage of Equipment

If the system will be off for a prolonged time period, water feed to the MIOX system should be turned off at the inlet to the water softener. In addition, the brine tank, tubes, and piping should be drained, and the brine pump should be flushed with clean water. The system can also be unplugged.

If the system is being shut down for the winter, the water softener should be protected from freezing, either by heating the room, removing the softener to a heated location, or draining the softener. If the SAL system is completely drained, the system itself does not have to be relocated. Draining includes the heat exchanger in the control panel, the electrolytic cell, the brine tank, and all piping. The brine pump should be purged with fresh water before draining. Dried salt in the brine pump head can cause startup difficulties when the unit is restarted. If compressed air is available (<50 psi; 345 kPa) blow out all passages. The heat exchanger in the control box will not drain enough to prevent it from freezing. Compressed air or a non freezing coolant should be added to the heat exchanger if the system will see freezing temperatures.

## IV.3. System Shutdown Procedure

This sequence for shutdown of the MIOX system is designed to properly flush the electrolytic cell and help maintain the overall condition of the MIOX equipment. When turning the system off for any period of time, it is important to follow this sequence:

1. Push in the red Mushroom / Master Switch.
2. Wait 30 seconds while the system performs a shut down purge cycle.

3. Purge the brine pump by isolating the brine generator outlet valve and disconnecting the suction line to the brine pump. Connect a water source to the suction side of the brine pump.
4. Start the system to flush the pump with brine-free water.
5. Turn the red mushroom button to the off position
6. Flip the "main" power switch to the OFF position.
7. Drain the oxidant tank(s) and drain controller and cell if freezing will be a problem.
8. Disconnect the power source

# V. Troubleshooting

This section outlines the most common system problems that require troubleshooting and maintenance. Specify fault alarms and recommended actions are also presented.

## V.1. Water Quality, Chemistry, and Hardness

The quality and chemistry of the raw water source plays a critical role in the disinfection effectiveness of the cell. Factors such as pH, hardness, temperature, microbial types, and turbidity vary greatly and affect the oxidant demand of each individual water system. These factors may need to be reanalyzed as part of the troubleshooting process, especially if significant changes to the water supply have occurred. Oxidant demand can only be accurately determined through an oxidant demand test. See Appendix D – Procedures, "Oxidant Demand Testing" for further information.

The raw water source may also impact the oxidant production of the MIOX system (See Appendix D – Procedures, "Water Quality") Because water quality can vary from season to season, **it is important that the "worst case" measures are used** in calculating the injection rate and determining if the water is the source of the problem. System feed water with hardness greater than 1 grain must be softened. Softened water enhances the life of the cell and reduces system maintenance. Although dissolved magnesium and calcium are responsible for causing hard water, other parameters should be measured to ensure they are below the system specs. If a value is exceeded, it may be possible to remove the substance from the source water stream using filters.

## V.2. Electrical Power

MIOX Corporation recommends placing each unit on its own circuit. High load, start-up devices, including pumps, compressors, and welders connected to the same circuit as the MIOX system could create power spikes, surges, and brown-outs problems. Required power specifications and conditions for a SAL series system are as follows:

- Reliable and transient free power
- Proper grounding
- Avoid ground loop conditions
- Avoid power spikes, surges, and brown-outs
- AC single phase and 50 or 60 Hz power
- Dedicated circuits for each system:
- 220 VAC conventional grounded 3-prong twist plug
- 110 VAC conventional grounded 3-prong plug

If the voltage variation to the SAL unit is greater than plus or minus 10 percent or is subject to power interruptions, electrical storms, nonstandard grounding, or harmonic

effects, MIOX Corporation recommends installation of a line conditioner, UPS, or lightning arrestor in order to protect the sensitive electronics in the control box. Line conditioning equipment is available from most electrical supply stores. The warranty will be void if a system failure *can be traced to a poor power source*. If you need technical assistance, please contact your local distributor or MIOX Corporation.

All MIOX Corporation units **require** a **good earth ground**, both for personal safety and safety of the unit. The surge protection devices inside the unit are ineffective without a good earth ground. A common point earth is the green wire in our power cable. Although the equipment may have both high voltage (110 or 220 VAC) and high current, it is safe if properly wired and installed.

**⚠WARNING All MIOX Corporation units <u>require</u> a good earth ground. A neutral is <u>not</u> a substitute for an earth ground. Electrical wiring to all MIOX Corporation units should be wired by a certified electrician and on a separate circuit from other power devices such as pumps. MIOX Corporation cannot be held responsible for units wired improperly or that fail to meet UL Standard for Safety or National Electric Code (NEC) requirements. If the unit is improperly grounded, the MIOX Corporation warranty is void.**

## V.3. Power Usage

The SAL cell runs at approximately 12 VDC with a power supply unit provided for that purpose. The other components, including the brine pump, the water solenoid, thermowell and the control board operate at approximately 24 VDC with a separate, but smaller, power supply. The system's duty cycle and daily power consumption are dependent upon the amount of oxidant solution required.

## V.4. Water Pressure and Line Conditions

The water feed line for SAL units must accommodate water flow to both the MIOX system and to the softener during regeneration. **A minimum SUSTAINED pressure of 25 psi is required to operate the SAL systems.** The pressure should never drop below 25 psi. **The maximum pressure should not exceed 100 psi (689 kPa).** For supply pressure over 100 psi (689 kPa), auxiliary pressure reduction is needed. The optimal pressure range is 35 to 75 psi (241-517 kPa) and the normal operating line pressure should not vary more than 10 psi (69 kPa)

Approximate required feed flow values are as follows:

| | |
|---|---|
| SAL-30 | 6.3 gph (23.8 Lph) |
| SAL-40 | 8.2 gph (31.0 Lph) |
| SAL-80 | 16 gph (60.6 Lph) |

***NOTE:*** **Feed water must be free of all particulate matter. The in-line brine and water filters should be installed before the water softener and before the MIOX unit.**

## V.5. Temperature Conditions

### V.5.1. Feed Water Temperature

If the water temperature goes below 50 °F (10 °C), the cell will be rendered inoperable within a short period of time. Problems resulting from cold temperature can be solved with an in-line heater. If the temperature exceeds the maximum of 85 °F (29 °C), chlorine production will not be affected, but the oxidants will volatilize more quickly in the oxidant solution tank. At even higher temperatures, the cell will be damaged, and the water-cooled heat exchanger will not be effective in cooling the power supply.

*NOTE:* Failure of the system that can be traced to improper temperature conditions is not covered under the MIOX warranty.

The thermowell not only monitors the inlet and outlet temperatures, the difference in temperatures between the cell inlet and outlet is monitored. The cell control logic utilizes a scheme whereby the power to the cell is constant under normal conditions. Under these conditions, the temperature rise through the cell has a direct correlation to the flow through the cell. If the cell flow drops, the temperature rise through the cell increases. Likewise, if the cell flow increases, the temperature rise decreases. This correlation between temperature rise and flow is very linear and consistent. By monitoring the cell differential temperature, flow through the cell is monitored. Cell flow can be influenced by a variety of things, including calcium carbonate buildup within the cell, inadequate water supply pressure to the system and fluid line leaks.

### V.5.2. Ambient Air Temperature

The ambient air temperature must **not**, under any conditions, drop below 35 °F (2 °C) or exceed 110 °F (43 °C). Temperatures outside of the optimal range (35 °F – 110 °F, 2 °C – 43 °C) can damage the system and render it inoperable, as well as reduce the operating efficiency. If the system is going to be stored indefinitely, all water lines should be drained. This is particularly important for the water cooled heat exchanger that provides cooling air flow for the main power supply located inside the power supply cabinet.

***NOTE:*** **Air temperature considerations must be based on the relative heat index, which accounts for both humidity and temperature.**

## V.6. Trouble Shooting Guide

**SOFT FAULTS**

| Problem | Possible Cause | Remedial Action |
|---|---|---|
| *1. Display Reads:* IN STANDBY | a) The system was put into standby manually. | a) Restart system by rotating the knob. |

| | | |
|---|---|---|
| **MASTER OFF (RED MUSHROOM)**<br><br>*Explanation:*<br>The system has been put into standby manually | | |
| 2. *Display Reads:*<br>**IN STANDBY**<br>**LOW $H_2$0 PRESSURE**<br><br>*Explanation:*<br>Insufficient feed water to the system. | a) Sudden loss of feed water to cell.<br><br>b) Low pressure surges in feed line due to main pump shutdown causes suction in supply line.<br><br>c) Blockage of feed line. | a) Ensure feed water valve is open. Check if water softener is working. Check for water leaks.<br><br>b) Ensure feed water supply pressure always exceeds 25 psi . Ensure feed water supply pressure is less than 100 psi. Check if water softener is working. Check for water leaks.<br><br>c) Check all tubing and piping for blockage and remove any obstructions. |
| 3. *Display Reads:*<br>**IN STANDBY**<br>**MIOX TANK OK**<br><br>*Explanation:*<br>Oxidant solution is between high and low level set-points. | a) Oxidants in solution tank are being used (normal operation). | a) Push MANUAL button to override and start unit again. (This will fill the oxidant tank until full.) |
| 4. *Display Reads:*<br>**IN STANDBY**<br>**MIOX TANK FULL**<br><br>*Explanation:*<br>Oxidant solution has reached the top level. | a) Solution tank is full (normal operation). | a) N/A |
| 5. *Display Reads:*<br>**IN STANDBY**<br>**BAD FLOAT**<br><br>*Explanation:*<br>Solution tank level switch not operating properly. | a) Top level switch stuck up and /or bottom level switch stuck down.<br><br>b) Electrical connections are loose.<br><br>c) Replace level switch assembly. | a) Check MIOX solution switch for free movement (both top and bottom).<br><br>b) Check level switch connections on the outside of the control cabinet & connections at the terminal blocks inside the control enclosure.<br><br>c) Replace level switch assembly. |
| 6. *Display Reads:*<br>**IN STANDBY**<br>**BAD 5V SUPPLY**<br><br>*Explanation:*<br>> 20% drop in AC power | a) Controller board failed.<br><br>b) 5V power supply failed on control board. | a) Contact your sales agent or MIOX Customer Support to order a new controller board.<br><br>b) Check 5V supply located on the controller board. If ≤5V, contact your distributor for replacement. Adjust for 5V setting. |

| | | |
|---|---|---|
| 7. *Display Reads:* **IN STANDBY BAD 24V SUPPLY**<br><br>*Explanation:* > 20% drop in AC power | a) Controller board failed.<br><br>b) 24V power supply failed. | a) Contact your sales agent or MIOX Customer Support to order a new controller board.<br><br>b) Check 24V supply (behind control panel display). If ≤24V, contact your distributor for replacement. Adjust for 24-25V setting. |

**HARD FAULTS**

| Problem | Possible Cause | Remedial Action |
|---|---|---|
| **8.** *Display Reads:* **ALARM HARD FAULT HI OXIDANT TEMP**<br><br>*Explanation:* Cell outlet temperature exceeds maximum temperature rating for 10 consecutive test cycles. | a) Extremely high temperature.<br><br>b) Chiller malfunction.<br><br>c) Cell amperage too high.<br><br>d) Cell flow rate too low.<br><br>e) Cell exit ports clogged. | a) Check the inlet temperature of the water and decrease it if it is exceedingly high.<br><br>b) Check to ensure the chiller is working<br><br>c) Verify display cell amps agree with measured cell amps from amp clamp.<br><br>d) Increase water flow to cell (open flow control valve on water manifold).<br><br>e) Acid wash cell to remove foreign particles that may clog the cell. |
| **9.** *Display Reads:* **ALARM HARD FAULT HI CELL CURRENT**<br><br>*Explanation:* Cell amperage exceeds maximum current rating for 10 consecutive test cycles. | a) Low water line pressure (< 25 psi; 172 kPa).<br><br>b) Pump not slowing down to reduce brine concentration. | a) Check water feed line pressure to system & increase feed water pressure to 25 psi (172 kPa) minimum.<br><br>b) Turn master switch/breaker off & back on. If system comes back on and pump is still running fast check pump voltage on pin 21 on interface block. If pump voltage is >2V, the controller board may be bad or pump may need replacing. |
| **10.** *Display Reads:* **ALARM HARD FAULT LOW CELL VOLTAGE**<br><br>*Explanation:* Cell voltage dropped >1V. | a) Extremely high current.<br><br>b) Bad cell power supply.<br><br>c) Fuse blown. | a) Test for various possible causes of high current.<br><br>b) Check cell power supply. Contact sales agent or MIOX Customer Support for replacement.<br><br>c) Replace fuse (20A). |
| **11.** *Display Reads:* **ALARM HARD FAULT LOW CELL CURRENT**<br><br>*Explanation:* Not enough cell amperage for more than 4 minutes. | a) Low brine concentration.<br><br>b) Brine pump air locked.<br><br>c) Brine pump frozen.<br><br>d) Brine filter clogged.<br><br>e) Controller board bad or brine pump worn out. | a) Check the salt, water & brine level in the brine tank. Add salt to the brine tank.<br><br>b) Use the brine primer bulb to pressure the brine feed line and flush air out of the brine line. If necessary, remove the tube on the inlet to the brine pump and purge the air from the brine line.<br><br>c) Remove debris from brine pump.<br><br>d) Flush out brine filter(s) and/or change filter(s).<br><br>e) Push Standby (mushroom) switch and restart system. If pump is still running fast, check pump voltage on pin 21 on controller board. If >2V, brine pump may need replacing or |

| | | |
|---|---|---|
| | | controller board is bad. |
| | f) System pressure too high (> 100 psi; 689 kPa). | f) Measure feed water pressure downstream of the softener. If pressure is >100 psi (689 kPa), add a PRV to the main line to bring pressure into the operating range (25-100 psi; 172-689 kPa). |
| | g) Failure of in-line adjustable PRV. | g) If feed water pressure is <100psi, measure pressure in the water manifold. If it varies ±2 from 15 psi (103 kPa), check the internal PRV for blockage or debris. If debris is found, clean the PRV and check the water filters. If no blockage is found, replace PRV. |
| | h) Cell life depleted. | h) Replace cell or increase MIOX injection rate. |
| | i) Salt too fine. | i) Replace the brine strainer with salt filtration device.<br>OR<br>Replace fine salt with coarse granular salt.<br>OR<br>Break apart existing salt bed. |
| **12.** *Display Reads:* **ALARM HARD FAULT VHI CELL CURRENT**<br><br>*Explanation:* Cell amperage exceeded excessive maximum current limit. | a) Low water line pressure (< 25 psi )<br><br>b) Pump not slowing down to reduce brine concentration.<br><br>c) Frozen water in the system. | a) Check water feed line pressure to SAL system and increase feed water pressure to 25 psi minimum for SAL series systems.<br><br>b) Push Standby switch (red mushroom) and restart system. If pump is still running fast, check Pin 21 on controller board for pump voltage. If > 2V, controller board is bad, or pump may need replacing. Call your sales agent for MIOX Customer Support.<br><br>c) Add heater to the room so that the ambient air temperature is above 35°F. Add water heater to feed water line system to minimum 50°F water temperature. |
| **13.** *Display Reads:* **ALARM HARD FAULT PWR SSR FAILURE**<br><br>*Explanation:* Solid stare relay(s) (SSR) cannot be turned off by the controller. | a) Solid state relay has been damaged. | a) Turn the system off manually. Contact your sales agent or MIOX Customer Support for SSR replacement.<br><br>Note: While this fault is active, the brine pump will be turned off, but the water feed solenoid valve will remain on with a one second on, one second off cycle. This provides cooling water flow through the cell that should prevent damage to the power supply and cell. However, water flow to the oxidant tank will cause dilution of the oxidant strength and possibly eventual overflow of the oxidant tank. |
| **14.** *Display Reads:* **SOLUTION TANK OVERFLOW**<br><br>*Explanation:* | a) Blocked solenoid.<br><br>b) Level switches not working.<br><br>c) Drain clogged, backing up | a) Disassemble to clean solenoid.<br><br>b) Check level switch wiring to ensure switch is functioning.<br><br>c) Clean out any obstructions in drain. |

| | | |
|---|---|---|
| Oxidants to tank is not turning off.. | into solution tank overflow. | |
| 15. *Display Reads:* **LOW CHLORINE**<br><br>*Explanation:* MIOX system production lower than normal, or chlorine residual in water system below normal. | a) High flow through cell.<br><br>b) Water flowing through cell while system in standby mode.<br><br>c) Injection system malfunction.<br><br>d) Cell life depleted.<br><br>e) Break in water distribution lines.<br><br>f) Water production exceeds max. for system design.<br><br>g) Oxidants stored too long before use. | a) Measure flow.<br><br>b) Unplug system power. Turn feed water supply off. Disassemble solenoid valve and check for obstructions.<br><br>c) Check injection of oxidant solution into water system.<br><br>d) Check cell amperage, flow, chlorine production, and salt consumption. Replace cell if necessary.<br><br>e) Check for leaks and repair.<br><br>f) Call sales agent or MIOX Customer Support.<br><br>g) Drain oxidant tank and start system again. Use fresh oxidants for injection. |
| 16. *Display Reads:* **NO DISPLAY VISIBLE**<br><br>*Explanation:* Power not getting to system. | a) Power to system interrupted (blackout, etc.)<br><br>b) 24V power supply failure. | a) Check and repair main power source and check external breaker.<br><br>b) Check 24V power supply output and its fuses with appropriate meter. (The power supply is located behind the displays in the control panel.) |

# *Appendix A – SAFETY*

## HYDROGEN SAFETY

**MIOX Liquid Barrier Venting and Dilution Air Systems have been engineered to ensure that hydrogen gas is maintained at <25% of the lower explosive limit in the oxidant tank. MIOX Corporation is the only On-Site Generation Disinfection Supplier to have sought the safety assessment of Hydrogen Safety, LLC (Newington, CT). MIOX Corporation has incorporated their safety expertise into their designs.**

**Explosive Properties of Hydrogen Gas:** The lower explosive limit (LEL) of hydrogen is 4.1% by volume in air. This means that any concentration of hydrogen in air less than 4.1% will not ignite (too "lean" in fuel). Likewise, the upper explosive limit of hydrogen is 74.2% by volume in air. This means that air containing greater than 74.2% hydrogen will not be explosive (too "rich" in fuel). Because this potential fuel source is produced in any electrolysis process, proper mitigation of hydrogen is mandatory for safe operation of on-site generation equipment. MIOX engineers all of its systems to vent hydrogen so that the concentration in the oxidant tank is always <25% of the LEL.

**Hydrogen Gas Generation in the Electrolytic Process:** Electrolytic cells of all types using water as a component of the fluid medium (i.e. brine) produce hydrogen gas at the surface of the cathode in the electrolytic reaction. The hydrogen generation rate is 6.96 milliliter per amp-minute per active anode electrode at standard temperature and pressure (0°C and 1 atmosphere pressure). The volumetric hydrogen generation rate increases in proportion to absolute temperature above 0°C, and is inversely proportional to barometric pressure. Hydrogen ($H_2$) is the lightest of the gases with a vapor density of 0.069 (relative to that of air taken to be 1.0) causing it to seek the highest point in a room or container in a normal room atmosphere.

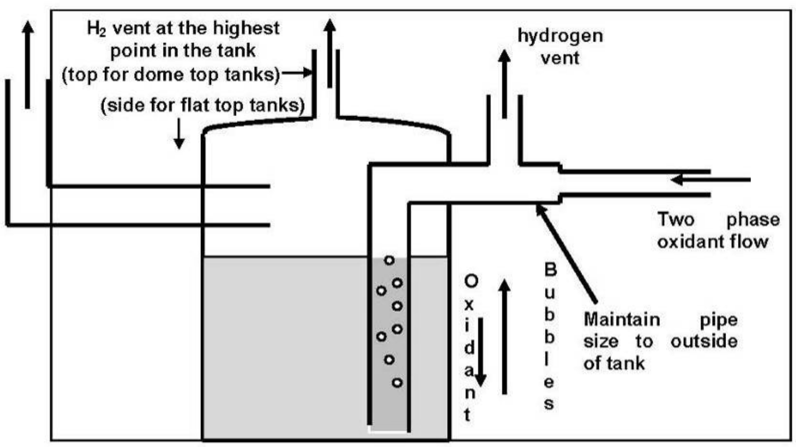


Figure 14. Liquid Barrier Hydrogen Safety System

**Liquid Barrier Vent System**

The Liquid Barrier Vent Safety System avoids the use of electric fans and motors as a potential for failure and/or as an ignition source near hydrogen. Liquid Barrier Vent systems utilize a gas trap design to prevent hydrogen gas generated from the electrolysis process from entering the oxidant storage tank system (see Figure 1). Each of the oxidant tanks is equipped with a drop tube in the oxidant tank that hydraulically locks the oxidant solution in the tank from the hydrogen. This is very similar to a "P-trap" system in household plumbing. The velocity of the oxidant stream in the drop tube is lower than the rate of bubble rise in the oxidant tube, so that all of the hydrogen gas is trapped and vented out of the system through the hydrogen vent piping that discharges external to the building.

The drop tubes are sized for each system to ensure hydrogen gas does not enter the oxidant tank. The drop tube diameter must be of adequate volume to ensure that the downward velocity of fluid is slower than the upward flow of bubbles in the liquid stream. In the event that the on-site generation system capacity is increased by adding additional cell modules, or increasing the size of existing cell modules, it is also very important to review the size of the drop tube. Additional oxidant generation capacity will increase the volume of fluid entering the drop tube, which may require that the drop tube diameter be increased to ensure effectiveness of the system. Consult MIOX customer service for adequate direction on how to do this.

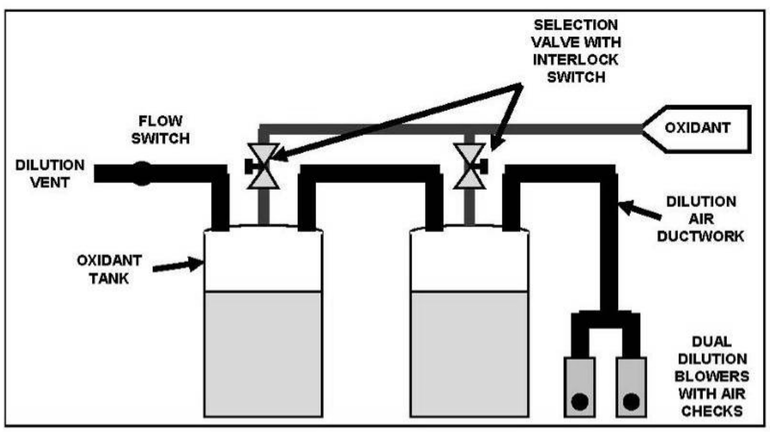


Figure 15. Dilution Air Safety System with Multiple Oxidant Tanks

**The Dilution Air System:**

MIOX offers an optional fan-driven dilution air vent system (see Figure 15). The Dilution Air System is typically used on mid to large sized systems. The Dilution Air System

is configured as a dual blower system with check valves and an air flow switch to provide indication of loss of air flow, as well as automatic switching to the backup blower in the event of a blower motor failure. Sizes are available in a variety of ductwork pipe diameters, and the system size is matched to the $H_2$ generation rates for the selected system. The Dilution Air System provides an additional safety measure for the mitigation of hydrogen related hazards. The system is intended to maintain a $H_2$ concentration that is less than 25% of the lower explosive limit. This is accomplished by sizing the Dilution Air system such that 100 parts of air are introduced for each part of hydrogen the MIOX generator produces.

Importantly, since both the liquid barrier $H_2$ vent and dilution air vent systems are sized according to the oxidant production capacity and the number of storage tanks, the design of the Dilution Air System needs to be re-evaluated if capacity is increased.

**Additional Hydrogen Safety Precautions:** While the MIOX systems have been engineered to operate at high levels of safety, it is important to observe the following guidelines of conduct whenever you are near the oxidant tank or the onsite generation system.

1. No smoking should be allowed anywhere near the oxidant tank or the on-site generation equipment.
2. No open flames or hot work should be permitted anywhere near the oxidant tank or onsite generation equipment (soldering, hot surfaces, etc.)
3. Static electricity generation should be avoided near the oxidant tank or onsite generator
4. The onsite generator equipment should be fully grounded.
5. All electrical equipment and connections used at or near the onsite generator should national electric code for class 1, group B, division 2.

## ELECTRICAL SAFETY

While MIOX Corporation's on-site generators are designed to minimize electrical hazards, **MIOX equipment should only be serviced by a certified MIOX technician. Do not attempt to troubleshoot an electrical problem without proper training. Follow all NEC guidelines on electrical safety. Be aware that local codes may supersede NEC guidelines.**

The voltage varies depending upon the size and manufacturer of on-site equipment.

1. The power cord should be specified for wet use.

# *Appendix B* – RECOMMENDED TOOLS FOR INSTALLATION AND RECOMMENDED SPARE PARTS

## RECOMMENDED TOOLS FOR INSTALLATION

1. Power Drill
2. Concrete Bit (to anchor unit to wall)
3. Small Flatblade Screwdriver (1/8" wide)
4. Medium Flatblade Screwdriver
5. Medium Phillips Screwdriver
6. Nut Drivers, Set
7. Channel Lock Pliers
8. Ratchet Wrench (English) with 10-12" Extension, Including Sockets
9. Crescent Wrench, Medium
10. Razor Knife
11. Spears blue 75 thread sealant
12. Copper Conductive Compound (e.g., Thomas & Betts – "KOPR-SHIELD")
13. Multimeter (VAC and VDC, Resistance, Continuity)
14. PVC Solvent Glue and Primer
15. PVC Pipe Cutter
16. FAC Test Kit (e.g., Hach DPD Color Wheel or Colorimeter)
17. Hardness Test Kit
18. Amperage Clamp (DC, 0-200 amp range minimum)
19. Thermometer
20. Spears blue 75 thread sealant Measure and/or Ruler
21. Wire Strippers
22. Wire Crimpers
23. File/Sandpaper (300 grit)

## RECOMMENDED SPARE PARTS

For two years of operation, the following spare parts are recommended.

**DESCRIPTION**

**Parts that MIOX supplies**

Push-in fitting for cell brine connection (3/8 NPT x 3/8 tube)
6 of water filter cartridge, 5 micron
6 of water filter housing
6 of brine filter, micron plated
6 of brine 10" filter housing
Brine pump
Spare replacement cell

**Parts that may easily be purchased locally**

Fuses, 20A, 250V, 3AB (SAL-80)
Tubing, 3/8" ID, 5/8" OD, 10 feet (cell to oxidant tank)
Hose clamps, plastic, 5/8 OD tubing

# *Appendix C – MIOX WARRANTY STATEMENT*

# WARRANTY STATEMENT

***Standard System Warranty:***

**WARRANTY** - MIOX Corporation warrants that the system components manufactured by MIOX will be free from defects in material and workmanship for one year. (Consumable items such as filter cartridges are not included.)

**PERIOD** - This warranty period will run 12 months from the start-up date or 18 months maximum from the date of shipment, whichever occurs first. Start-up date confirmation is required to support any warranty claims made 12 months after shipment.

***Standard Cell Warranty:***

**WARRANTY** - MIOX Corporation warrants that the electrolytic mixed-oxidant cell will be free from defects in material and workmanship for two years. The warranty further extends from the end of year two to the end of year five on a prorated basis.

**REPLACEMENT PRICING** - The prorated price is determined by multiplying the price of a replacement cell by the number of months the warranted cell was used, and then dividing by 60. For example, a cell replaced after 36 months would be priced at (Replacement Cell Price) x 36/60 = Warranty Price.

**PERIOD** - This 5 year warranty period begins on the date of shipment. If a warranty card *(yellow in color)* is received within 10 days of the cell's installation, the 5 year period will start on the date of installation. The period for a cell warranty is from the date of the warranty of the original purchased cell. Any cells provided by MIOX under the full coverage warranty to repair or replace a defective cell will be warranted from the start date of the warranty of the original purchased cell. If a replacement cell with new anode and cathode is purchased after 2 years, a new full warranty is included.

Alternatively, the customer can choose to have their existing cell repaired, in which case the existing warranty continues. A cell repair quote is available from customer service.

REPAIR PRICING **– Each component within the cell has a different replacement cost and requires labor and material for repair. Estimates for repair can be obtained from customer service after the cell in question has been returned for inspection.**

***General Information:***

**REPLACEMENT OR REPAIR** - MIOX Corporation's responsibility under these warranties is to correct by repair or replacement, at the option of MIOX Corporation, any such defect, disclosed on examination by MIOX Corporation or its representative, which developed under normal use during the warranty period.

**VOIDING THE WARRANTY** - MIOX Corporation reserves the right to revoke a warranty, based on breach of warranty conditions:

- lack of routine maintenance;

- improper installation, shelter, or service;
- modification performed by other than MIOX Corporation or its authorized representatives;
- abuse, accident, or neglect; or
- usage other than as recommended in the product manual and system documentation.

**AGREEMENT AND TRANSACTIONS** – Warranty service is provided by MIOX or an authorized representative of MIOX. MIOX offers this warranty to the owner of the MIOX equipment. If warranty service is required, service can be obtained by contacting your local MIOX distributor or MIOX customer service department.

**MIOX RESPONSIBILITY** - This warranty is in lieu of all other warranties covering the products, expressed or implied, including those of fitness and merchantability. MIOX Corporation shall not be held liable for consequential or incidental damages. This warranty, the invoice terms, and the order acknowledgment terms constitute the entire agreement between the customer and MIOX Corporation unless specifically agreed to in writing by both parties.

**DESIGN CHANGES** - MIOX Corporation reserves the right to make design changes, additions to, and improvements upon any of our products, and has no obligation to make the same changes, additions, or improvements on any products previously purchased.

**PRODUCTS TO BE REPAIRED OR REPLACED** -

- must be shipped / delivered to MIOX Customer Service at the Corporate offices in Albuquerque, New Mexico.
- must have a return merchandise authorization number from MIOX Corporation, which is obtained through your service representative.
- must include in the package a statement covering the nature of the malfunction, the name and phone number of the person returning the unit, and the address to which the warranty equipment should be returned.
- should be shipped in the original packaging or its equivalent to provide adequate protection.
- must be returned all transportation charges prepaid.
- will be returned to the end user with standard freight and handling charges for warranty replacement components paid by MIOX Corporation.

# *Appendix D – PROCEDURES AND TECHNICAL PAPERS*

MIOX

# OXIDANT DEMAND TESTING

The oxidant demand of water is a measure of the amount of oxidants needed to properly disinfect water. This value is extremely important for accurately sizing and maintaining MIOX equipment. Oxidant demand is determined by adding on-site oxidants in several concentrations to raw untreated (sample) water and measuring the FAC over time.

## Equipment Needed

100 mL graduated cylinder
Four (4) 100 mL glass jars with lids
Pipette that can accurately measure 0.1 mL increments
Chlorine test kit (i.e., DPD, Color Wheel, Colorimeter, or AccuVac)
Timer or a watch
Calculator

## Identify Starting Range

The initial oxidant demand test should use a 5 ppm dose to identify the correct starting range. If a 5 ppm dose is consumed in less than 30 minutes, the demand of the water is greater than 5 ppm, and dose rates of 10, 15, and 20 ppm should be used for testing. Conversely, if the 5 ppm dose is only moderately decreased in 30 minutes, testing should be performed with 1, 3, and 5 ppm doses.

Use the following formulas to determine the amount of oxidant and sample water to use (based on 100 mL samples), where X is the dilution factor.

Dilution Factor (X) = Oxidant FAC/Dosage
mL of Oxidant = 100/X
mL of Sample Water = 100 - (100/X)

(Oxidant FAC is the concentration of the on-site oxidant solution, which varies with each MIOX system model. The output of each unit should be measured, according to the procedure for Chlorine Testing, to determine the exact concentration of the on-site oxidant solution and catholyte.)

***Example:***

1.) Determine the amount of oxidant and sample water to be used. Always start with a 5 ppm dose for the first test. Suppose you are using a MIOX system that just generated an oxidant solution concentration of 250 ppm. First, you must determine the dilution factor (X):

**Dilution Factor (X)** = Oxidant FAC/Dosage = 250/5 = **50**

Next, determine the mL of oxidant and sample water to be used based on X:

**mL of Oxidant** = 100/X = 100/50 = **2 mL**
**mL of Sample Water** = 100 - (100/X) = 100 - (100/50) = 100 - 2 = **98 mL**

Thus, add 2 mL of oxidants to 98 mL of sample water for the first FAC reading.

> 2.) Determine the dosages for subsequent measurements. First dilute the oxidants as determined above, and after 30 minutes, take an FAC reading. If FAC is unmeasurable, this means all of the oxidants have been consumed, and you need doses of 10, 15, and 20 ppm for subsequent measurements; otherwise, if FAC has not significantly diminished, use 1, 3, and 5 ppm doses for subsequent testing. In this case, let's assume that the reading was 2.5 ppm after 30 minutes, indicating that you should use test dosages of 1, 3, and 5 ppm.

## Setup Calculations

Use the formulas given above to determine the amount of oxidant and sample water to use (based on 100 mL samples) for each of the doses. The sum of your oxidant and sample water volumes should add up to 100 mL since it provides enough volume for multiple FAC measurements at the various testing times.

***Example:***

Determine the oxidant and sample water volumes for the 1, 3, and 5 ppm doses. Assume the MIOX system is still generating an oxidant solution concentration of 250 ppm.

| | 1 ppm dose: | 3 ppm dose: | 5 ppm dose: |
|---|---|---|---|
| **Dilution Factor (X)** | 250/1 = **250** | 250/3 = **83.3** | 250/5 = **50** |
| **mL of Oxidant** | 100/250 = **0.4** | 100/83.3 = **1.2** | 100/50 = **2** |
| **mL of Sample Water** | 100 - 0.4 = **99.6** | 100 - 1.2 = **98.8** | 100 - 2 = **98** |

For a 1 ppm dose, 0.4 mL of oxidant should be mixed with 99.6 mL of sample water.
For a 3 ppm dose, 1.2 mL of oxidant should be mixed with 98.8 mL of sample water.
For a 5 ppm dose, 2.0 mL of oxidant should be mixed with 98 mL of sample water.

## Procedure

Stagger preparation of each dilution by several minutes to allow enough time for accurate analysis of FAC of each dilution at the specified time intervals. FAC readings should be taken at the following times: T = 0, 30 minutes, 60 minutes, and 90 minutes. Readings beyond 90 minutes are determined by interpretation of data from the first 90 minutes.

- Accurately measure the volume (mL) of calculated sample water and place in a glass jar.
- Accurately measure the volume (mL) of oxidant required.
- Add oxidant to sample water jar and swirl very briefly to mix.
- Immediately measure and record the FAC concentration and time the reading was taken (time = 0).
- Repeat the above steps for the other dilutions, measuring each at time = 0 before preparing the next dilution, and then take FAC readings for each sample at 30, 60, and 90 minutes. Generate a table similar to the one given in the example below.

***Example:***

Fill out the table properly and completely. First, the MIOX solution must be diluted to 1 ppm, 3 ppm, and 5 ppm dosages as determined in the previous example. The FAC residual of each dilution is then measured in 30-minute intervals until the chart is filled out as below (measurements are based on assumed tests for this example):

| | Sample A (1 ppm) | Time (o'Clock) | Sample B (3 ppm) | Time (o'Clock) | Sample C (5 ppm) | Time (o'Clock) |
|---|---|---|---|---|---|---|
| **t = 0** | 0.4 | 12:00 | 2.1 | 12:05 | 4.0 | 12:10 |
| **t + 30 min.** | 0.08 | 12:30 | 2.0 | 12:35 | 2.5 | 12:40 |
| **t + 60 min.** | 0.0 | 1:00 | 2.0 | 1:05 | 2.5 | 1:10 |
| **t + 90 min.** | 0.0 | 1:30 | 1.8 | 1:35 | 2.4 | 1:40 |

## Oxidant Demand Determination

After 90 minutes, determine which sample has the FAC residual nearest to the desired residual specified by the water system operator. If a desired residual is unknown, look for a FAC slightly greater than 0.2 ppm, which is usually the standard required by the state.

Subtract the selected FAC reading from the initial FAC dose for the corresponding sample. This signifies how much of the oxidants were consumed by the water and thus how much of an oxidant demand there is in the sample water.

***Example:***

Determine the oxidant demand of the water. In this case, let's assume the operator wants a 1.0 FAC residual in the water system. Looking at the bottom row (t + 90 minutes) of the chart filled out above, note that Sample B at 1.8 ppm is closest to the desired residual. The initial FAC dose in this case was 3 ppm, so the **oxidant demand** of this water is **1.2 ppm** (3.0 - 1.8 = 1.2). *(This means that the operator must dose at 2.2 ppm (1.2 + 1.0 = 2.2) to achieve his desired residual of 1.0 ppm.*

## *WATER QUALITY*

Knowing what to look for when troubleshooting will assist in the process. Most of the items on the following list will be below the limits but should be checked nonetheless. Concentrations or measurements in brine feed water and/or treated water that are less than the stated limits are not anticipated to have the stated effect. These factors can affect the oxidant demand of each individual water system, the oxidant production of the MIOX system, or the life of the cell itself. It is important to use "worst case" measures since water quality can vary from season to season.

| | MEASURE | LIMIT | WHAT IS IMPACTED | | |
|---|---|---|---|---|---|
| | | | Oxidant Demand | Chlorine Production | Cell Life |
| **TDS*** | mg/L | 200 mg/L | | X | |
| **Alkalinity*** | mg $CaCO_3$/L | 400 mg/L | | X | |
| **Total Hardness**** | mg/L (or grains/gal) | < 17.1 mg/L (1 grain) | | X | X |
| **Iron (Fe)**** [i] | mg/L | < 1 mg/L | X | | X |
| **Manganese (Mn)**** | µg/L | < 50 µg/L | X | X | X |
| **Fluoride (Fl)** | mg/L | < 1 mg/L | | | X |
| **Silica ($SiO_2$)** | mg/L | < 80 mg/L | | X | X |
| **Bromide** | mg/L | < 50 mg/L | | | X |
| **Cyanide** | mg/L | < 1 mg/L | | | X |
| **Lead** | mg/L | < 2 mg/L | | | X |
| **Tin** | mg/L | < 20 mg/L | | | X |
| **Dissolved Sulfides (as $H_2S$)** | mg/L | *** | X | | |
| **Ammonia Nitrogen ($NH_3$-N)** | mg/L | *** | X | | |
| **Organic Nitrogen (Org-N)** | mg/L | *** | X | | |
| **Total Organic Carbon (TOC)** | mg/L | *** | X | | |
| **pH** | - | 5 - 9 | | X | X |
| **Water Temperature Range (for MIOX Series)** | °C (or °F) | > 10°C < 24°C (> 50°F < 75°F) | | X | X |
| **Water Temperature Range (for SAL Series)** | °C (or °F) | > 10°C < 29°C (> 50°F < 85°F) | | X | X |

* If TDS > 200 or Alkalinity > 400 then chlorine production could be impacted. Use of a dealkalizer (anion resin) may be needed.
** Cation water softeners will remove these components up to a limit. See references to maximum ferrous iron and manganese in water softener documentation. Total hardness affects cell life only in that higher hardness requires acid washing to remove carbonate deposits from the cell. Use of water softened to < 1 grain hardness should not require acid washing of the cell.
*** Oxidant demand is affected by <u>any</u> level of $H_2S$, ammonia or organic nitrogen, or TOC.

[i] Iron may deposit Fe(OH)3 on the anode, causing an electrical "blind", which would increase the brine pump signal voltage (brine pump speed) needed for the system to reach the operating window. Chlorine production

would remain the same, but salt conversion efficiency will decrease. The same effect is true of silica on the cathode.

# TOTAL DISSOLVED SOLIDS (TDS)

Questions often asked about the use of MIOX-generated mixed-oxidant and hypochlorite solutions for disinfection of potable water concern the addition of sodium chloride (NaCl) with the mixed-oxidant or hypochlorite solution; how much the Total Dissolved Solids (TDS) will increase in the treated water with various additions of mixed-oxidant or hypochlorite solution; how much different is the increase in TDS using MIOX on-site generators versus using chlorine or sodium hypochlorite solution; and what are the relative proportions of sodium ($Na^+$) and chloride ($Cl^-$) added. The purpose of this note is to describe and give examples of the chemistry and calculations involved in addressing these questions.

**USING MIXED-OXIDANT OR HYPOCHLORITE SOLUTION**

The MIOX System generates mixed oxidants or hypochlorite from an 8 - 30 g/L sodium chloride (NaCl) brine. (The brine concentration varies from system to system.) The disinfectant generated is injected into the water to provide disinfection. The main disinfecting oxidant ingredient of both the mixed-oxidant and hypochlorite solutions is chlorine generated electrolytically and dissolved in the brine forming $Cl_2$, HOCl, and $OCl^-$ with the proportions of the species present being pH-dependent. At the pH of the solutions, the major chlorine species present are dissolved HOCl and $OCl^-$. Other oxidants that are thought to be generated in minor concentrations in the mixed-oxidant process (but have been shown to be not present in the mixed-oxidant solution) include ozone ($O_3$) and chlorine dioxide ($ClO_2$); these oxidants are significant from the standpoint of disinfection effectiveness but are quantitatively insignificant for the purposes of estimating additions of dissolved ions to the water.

The chlorine species, measured as Free Available Chlorine (FAC), are typically generated to a concentration of about 3600 to 4000 mg/L in the mixed-oxidant solution and about 8000 mg/L in the hypochlorite solution. The unelectrolyzed NaCl is carried along with the FAC injection into the water.

In the water, the oxidants react with various reductants, also known as chlorine or oxidant-demanding substances, in the general reaction

$Cl_2$ + reduced substances $\rightarrow$ oxidized substances + 2 $Cl^-$

There are also losses of chlorine from the water by direct substitution onto organic compounds to form chlorinated organics and, with further reaction, trihalomethanes (THMs) and other chlorinated organic compounds of concern to human health. But these losses (which do not return $Cl^-$ to the water) typically amount to < 0.1 mg/L, that is much less than 5% of the total FAC dose, and can be neglected for purposes of this discussion.

Because the chlorine added to the water, for all practical purposes, is added in total to the water ultimately as chloride ($Cl^-$), and there are no losses of sodium or chloride in the mixed-oxidant solution generation process, the NaCl concentration added to the water with

mixed-oxidant or hypochlorite solutions can be calculated simply as the NaCl concentration of the brine multiplied by the ratio of the volume of disinfectant solution injected per unit volume of water treated. This injection ratio is determined by the FAC dose desired. For example, using a mixed-oxidant solution containing an FAC concentration of 3400 mg/L, to dose the water at a 5 mg/L FAC concentration, the injection ratio would be

**Injection Ratio = Desired FAC Dose (mg/L) ÷ Mixed-Oxidant Solution FAC Concentration (mg/L)**

Injection Ratio = 5 mg/L ÷ 3400 mg/L = 1/680

That is 1 unit volume of mixed-oxidant solution for each 680 unit volumes of water to be treated, e.g. 1 gallon per 680 gallons. In the example, the increase in NaCl concentration, and TDS, by the mixed-oxidant solution injection would be as follows:

**Increase in TDS = Brine NaCl Concentration x Injection Ratio**

Increase in TDS = 14,995 mg/L x 1/680 = 22.05 mg/L

The relative proportions of sodium ($Na^+$) and chloride ($Cl^-$) added are calculated from the molecular weights:

**Increase in $Na^+$ = Increase in NaCl x (Molecular Weight of $Na^+$ / Molecular Weight of NaCl)**

Increase in $Na^+$ = 22.05 mg/L x (23.00 / 58.45) = 8.6 mg/L

**Increase in $Cl^-$ = Increase in NaCl x (Molecular Weight of $Cl^-$ / Molecular Weight of NaCl)**

Increase in $Cl^-$ = 22.05 mg/L x (35.45 / 58.45) = 13.45 mg/L

Naturally, the sum of the increase in $Na^+$ and the increase in $Cl^-$ is the increase in NaCl, and TDS, 22.05 mg/L.

**USING CHLORINE GAS**

The use of chlorine gas ($Cl_2$) will also increase the TDS of the treated water. $Cl_2$ participates in the general reaction illustrated above; thus an FAC dose of 5 mg/L add as $Cl_2$ as in our example, will ultimately lead to an increase in the $Cl^-$ concentration (and therefore the TDS) of 5 mg/L. This is not the end of the chemistry, however. Charge balance must be maintained in solution; thus the negative charges added by the $Cl^-$ anions must be balanced by an equal number of positive charges added by cations. Some of the positive charge required will be provided by positively-charged oxidized substances noted in the general reaction. But more often, the required positive charges are supplied by cations dissolved into the water from particulates also in the water, resulting in an even greater increase in the TDS. As both an approximation and an illustration, let us assume that the required positive charges are supplied by $Na^+$ dissolving from particulates into solution. The concentration of $Na^+$ required for charge balancing can be calculated from the equivalent weight of $Na^+$, the molecular weight divided by the charge.

**Increase in $Na^+$ = Increase in $Cl^-$ x (Equivalent Weight of $Na^+$ / Equivalent Weight of $Cl^-$)**

Increase in $Na^+$ = 5 mg/L x (23.00 / 35.45) = 3.2 mg/L

Thus, in our example, the increase in TDS in the treated water using $Cl_2$ gas for disinfection is the sum of the $Cl^-$ added and the $Na^+$ added for charge balancing; 5.0 mg/L $Cl^-$ plus 3.2 mg/L $Na^+$ equals 8.2 mg/L TDS.

**USING BULK SODIUM HYPOCHLORITE SOLUTION**

Increases in $Na^+$, $Cl^-$, and TDS caused by the use of commercial sodium hypochlorite (NaOCl) bleach solution for disinfection are the same kind as those added by mixed-oxidant or hypochlorite solutions. Commercial bleaches are made by electrolysis of a sodium chloride (NaCl) solution, similar to the process used in on-site generation. The TDS of the bulk bleach is typically not reported but it can be estimated from the specific gravity of the product as reported on the packaging.

The specific gravity of a commercial bleach solution known as a "15 Trade Percent Available Chlorine" (150 g/L available chlorine) is about 1.21. The TDS of a NaCl solution having this specific gravity is about 300 g/L.

The injection ratio for a 5 mg/L FAC dose of this solution would be as follows:

Injection Ratio = 5 mg/L ÷ 150,000 mg/L = 1/30,000

The TDS added would be 300,000 mg/L x 1/30,000 = 10.0 mg/L

The relative proportions of sodium ($Na^+$) and chloride ($Cl^-$) added are calculated from the molecular weights:

**Increase in $Na^+$ = Increase in NaCl x (Molecular Weight of $Na^+$ / Molecular Weight of NaCl)**
Increase in $Na^+$ = 10.0 mg/L x (23.00 / 58.45) = 3.9 mg/L

**Increase in $Cl^-$ = Increase in NaCl x (Molecular Weight of $Cl^-$ / Molecular Weight of NaCl)**
Increase in $Cl^-$ = 10.0 mg/L x (35.45 / 58.45) = 6.1 mg/L

**SUMMARY**

The increases in $Cl^-$, $Na^+$, and TDS resulting from the use of mixed-oxidant solution (generated in a 15 g/L NaCl brine to an FAC concentration of 3600 mg/L), chlorine gas, and commercial sodium hypochlorite solution to provide an FAC dose of 5 mg/L to water are summarized in the table below. The increases actually encountered in any given water are proportional to the desired FAC dose and can be calculated from those illustrated.

$Na^+$, $Cl^-$, and TDS Increases in Treated Water at 5 mg/L FAC Dose for Each Disinfection Alternative

| | INCREASE IN CONCENTRATION (mg/L) | | |
|---|---|---|---|
| DISINFECTANT | CHLORIDE | SODIUM | TDS |
| Mixed-Oxidant Solution | 13.45 | 8.6 | 22.05 |
| Chlorine Gas | 5.0 | 3.2 | 8.2 |
| Commercial Sodium Hypochlorite | 6.1 | 3.9 | 10.0 |

Increases due to use of mixed-oxidant or hypochlorite solution will vary also with performance of the MIOX System. Moreover, most MIOX System users find that the FAC dose, added as mixed-oxidant solution, required to maintain a satisfactory disinfection residual in their distribution systems is about 30% lower than the FAC dose required using any other disinfectant. Thus, in most cases, the increases in $Cl^-$, $Na^+$, and TDS using the mixed-oxidant solution are less than those illustrated above by about 30%.

The additions of $Na^+$, $Cl^-$, and thus TDS, increase the concentrations of those species in the distributed water over their background concentrations in the raw water. Concentrations of these species in raw water vary from place to place but it is rare to find a raw water supply that contains TDS less than 150 mg/L and sodium and chloride concentrations less than several 10s of mg/L. Thus, most users can expect increases in TDS of about 10% or less in using MIOX mixed-oxidant or hypochlorite solutions for disinfection and increases in TDS of slightly less using other typical disinfectants. These increases do not violate any current drinking water standards and do not increase the taste of the water to a threshold noticeable to the consumer.

The example calculations presented above were to illustrate the additions of $Na^+$, $Cl^-$, and TDS using MIOX mixed-oxidant systems relative to those additions using commercial sodium hypochlorite solution or chlorine, all dosed at the same FAC of 5 mg/L. Current MIOX systems available have different operating specifications; thus it is useful for the user to know the additions of $Na^+$, $Cl^-$, and TDS for each MIOX system. The table below calculates the additions for each MIOX system ***on a 1 mg/L FAC dose basis***.

**$Na^+$, $Cl^-$, and TDS Increases in Treated Water at 1 mg/L FAC Dose for Each MIOX System**

| **MIOX System Operating Parameters** | **Increase in Concentration per 1 mg/L FAC Dose** | | |
|---|---|---|---|
| | $Na^+$ | $Cl^-$ | TDS |
| | mg/L | mg/L | mg/L |
| SAL-30, 40, & 80 | 1.5 | 2.3 | 3.7 |
| MIOX-25N, 50N, & 100N | 1.8 | 2.8 | 4.5 |
| MIOX-250N & 500N | 1.1 | 1.8 | 2.9 |
| HYPO-5, 10, & 20 | 1.4 | 2.1 | 3.5 |
| HYPO-50N, 100N, & 200N | .8 | 1.2 | 2.0 |
| HYPO-500N & 1000N | 1.0 | 1.6 | 2.6 |

## *CHLORINE PRODUCTION TESTING*

Even though MIOX systems produce a mixed oxidant disinfectant, calculating chlorine production alone is the easiest way of checking the performance of a MIOX mixed-oxidant or MIOX sodium hypochlorite system. A cell yielding a reading of 3200 ppm when it should be reading 3600 ppm may not be old and depleted – the flows may just be high.

**Total Production = Chlorine Concentration X Volumetric Flow per unit time**

Follow the steps below to correctly determine the chlorine production of the system.

### Equipment Needed

- 250 mL glass beaker
- 500 mL, 1000 mL, 2000 mL, or 4000 mL glass jar with lid (depending on MIOX unit being tested)
- Pipette that can accurately measure 0.5 mL or 1 mL samples
- Chlorine Test Kit (i.e. DPD, Color Wheel, Colorimeter or AccuVac)
- Chlorine Demand-Free Water (see below)
- Graduated Cylinder (500 mL for SAL Systems, 1000 mL for MIOX Series mixed-oxidant or sodium hypochlorite systems)
- Timer or a watch with a second hand
- Calculator

### Preparing Chlorine Demand-Free Water

Demand-free water is required for determination of oxidant concentration in an on-site generator. Because the oxidant is being diluted significantly, any demand in the dilution water will cause a significant misreading in the oxidant concentration. There are two methods for making demand-free water. The first, and preferred, method requires UV exposure over an extended period and may not be practical for quick analysis. The second method is quicker, but the calculations must be modified to account for the excess chlorine residual in the water. Note that distilled water, whether purchased at the store or made in a lab, cannot be trusted to be demand-free.

<u>Method One:</u>

1. Add 5mL of 5.25% bleach into one gallon of distilled water.
2. Shake to mix thoroughly.
3. Allow the water to sit 2 days inside.
4. After 2 days inside, move the water outside where it will be exposed to direct sunlight since ultraviolet light reduces chlorine to chlorides.
5. Test a sample for chlorine and allow to sit longer in direct sunlight if chlorine is still present.

<u>Method Two:</u>

1. Add 3 mL of oxidant solution into one gallon of distilled water.
2. Shake to mix thoroughly.
3. Allow the water to sit for thirty minutes.
4. Check the chlorine residual in the water.
5. If there is no chlorine residual in the water, add another 3 mL, and wait another thirty minutes.

6. If there is a chlorine residual, record the value and wait another 15 minutes.
7. Check the chlorine residual again. If the chlorine value is the same as the last reading, the chlorine demand in the water has been met and the water is stable.
8. If the chlorine value is different than the last reading, wait 15 minutes and check it again. Repeat this procedure until the chlorine residual is stable.
9. Record the final chlorine residual value for use in the analysis that follows.

## Measuring Chlorine Concentration

1. Fill the 250 mL beaker with approximately 200 mL of mixed-oxidant or sodium hypochlorite solution.
2. Rinse the jar several times with chlorine demand-free water and then fill to the 2500 mL, or 5000 mL line with demand-free water, depending on which dilution technique you are using:
   - **SAL-30, 40, 80:** Use a 1:2500 dilution ratio (= 1 mL solution to 2500 mL water or 2 mL solution to 5000 mL of water).
   - **MIOX-250, 500, 1000 Series:** Use a 1:2500 ratio (= 1.0 mL solution to 2500 mL water or 2 mL solution to 5000 mL water.)
   - **HYPO Series Systems:** Use a 1:5000 ratio (= 1 mL solution to 5000 mL water)
3. Rinse the pipette several times by drawing in several mL of mixed-oxidant or sodium hypochlorite solution and discarding it.
4. With the pipette, accurately measure the solution sample needed (according to the dilution technique used above) and add to the jar containing demand-free water.
5. Cap and shake the jar several seconds to mix thoroughly.
6. Using the solution from the jar, take a reading by following the directions provided with the test kit.
7. For demand-free water created using:
   - Method One (no chlorine residual in water): For the chlorine residual value obtained in step #6 above, multiply by the dilution ratio used in step #2.

     | |
     |---|
     | Example: The chlorine reading from Step #6 was 1.75 mg/l, and the dilution ratio used was 1:2500. Chlorine concentration is: 1.75 mg/L x 2500 = 4375 mg/L |

   - Method Two (chlorine residual present in dilution water): Subtract the chlorine residual value obtained in step #6 above by the chlorine residual value measured in the demand-free water to determine the net chlorine value. Next, multiply this net chlorine value by the dilution ratio from Step #2 to get the chlorine concentration of the oxidant.

     | |
     |---|
     | Example: The chlorine reading from Step #6 was 2.25 mg/L, the chlorine residual measured in the demand-free water was 0.5 mg/L, and the dilution ratio used was 1:2500. Chlorine concentration is: 2.25 mg/L – 0.5 mg/L = 1.75 mg/L net; 1.75 mg/L x 2500 = 4375 mg/L |

8. Repeat this process three times, take the average of these readings and assign this value to X to calculate chlorine production.

## Measuring Flow

Total production of a system is the product of the concentration of the solution (determined above) and the volumetric flow of the solution over a period of time. Low

concentrations of oxidant solution are often erroneously associated with low production. In order to calculate the total production, for the system the he flow rate must also be determined and adjusted if necessary.

1. Remove the tubing that feeds the day tank and insert into the graduated cylinder for exactly *30 seconds*.

2, Record the number of milliliters (mL) collected in the 30 second time period.

3. Assign the number recorded in step 2 to F in the equation below to determine the flow of solution (Y) in GPH:

$$Y = F\frac{\text{ml}}{\text{30 seconds}} \times \frac{\text{60 seconds}}{\text{1 minute}} \times \frac{\text{60 minutes}}{\text{1 hour}} \times \frac{\text{1 liter}}{\text{1000 ml}} \times \frac{\text{1 gal}}{\text{3.79 liters}}$$

**OR**

Y=(F)0.0316622

If the flow is measured for only *15 seconds*, the multiplication factor will be as follows:

Y=(F)0.0633244

## Calculating Chlorine Production

Chlorine production is a function of concentration *and* flow. To calculate daily chlorine production (Z) in lbs:

$$Z = X\frac{\text{mg}}{\text{liter}} \times \frac{\text{3.79 liters}}{\text{1 gal}} \times Y\frac{\text{gal}}{\text{hour}} \times \frac{\text{24 hr}}{\text{1 day}} \times \frac{\text{1 lb}}{\text{454000 mg}}$$

**OR**

Z=(X)(Y)0.0002

Where the sample solution variables are:
X = mg/L chlorine concentration
Y = gph flow

## INJECTION SYSTEM OVERVIEW

Determining the correct amount of on-site oxidant solution necessary to disinfect the untreated or raw water is dependent upon several measurable factors including:

1) OXIDANT DEMAND:
   - Types and amounts of microorganisms in the water.
   - Water quality and chemistry – such measures as the turbidity and color, total organic carbon (TOC), pH, total dissolved solids (TDS), hardness, and biological or chemical oxygen demand (BOD or COD).
   - Physical characteristics such as temperature.
2) CELL FAC CONCENTRATION:
   - FAC concentration varies with each MIOX model size and must be considered when calculating the injection rate.
3) CONCENTRATION X TIME:
   - Concentration x Time (CT) is the residence time in the distribution line – that is, the flow time between when raw water is introduced into the system and when the first user connects to the system. Inactivation of microorganisms is a function of the concentration (C) of the oxidant and the time (T) the oxidant is exposed to organisms in the water. Consult your local regulatory agency for proper CT values.
   - Chlorine CT values are used with MIOX systems. However, users tend to see a quicker inactivation rate with on-site oxidants than with chlorine.
4) DESIRED CHLORINE RESIDUAL:
   - For potable water applications, the required residual will be a function of the CT values and chlorine residual required by the federal or state regulatory agency. The U.S. EPA requires a detectable chlorine residual at all points in the distribution system and a maximum of 4.0 mg/L. Normally, most states require a 0.2 ppm chlorine residual at all points in the distribution system.
   - For swimming pool and spa applications, in order for the unit to be NSF-listed, the output setting must be sufficiently high to maintain a minimum of 2.0 ppm residual chlorine.

⚠WARNING **It is critical to use the correct amount of MIOX solution in the raw water in order to adequately remove any water-borne microorganisms that may cause illness or death.** Before installing or operating MIOX, the factors described in the preceding points must be measured so that the correct Concentration x Time (CT) values can be calculated. Measurements can usually be obtained from governmental health authorities, a licensed professional engineer, or water analysis laboratories. **CT values should be calculated by a competent health professional, professional engineer with water systems expertise, or other such qualified professional.**

### Injection Method

It is advisable to utilize a **venturi injector**, if possible, because of low cost and ease of maintenance. If the water system has a **steady flow rate**, it qualifies for a venturi injection system. A venturi injector uses differential pressure to draw on-site oxidants into the water

stream. A booster pump is often used to increase the injector inlet pressure. The most common configuration is a sidestream injector, although many other configurations are possible.

Water systems with a **variable flow rate** normally utilize a **chemical feed pump**. These pumps typically are controlled by a 4 to 20 milliamp signal from a controller (e.g., chlorine monitor, ORP monitor, or flow meter), which adjusts the pump rate accordingly. Multiple venturi injectors and hybrid systems combining chemical feed pumps with venturi injectors are also possible.

## Injection Rate

The injection rate must be determined according to:

1. The **oxidant demand** of the water
2. The desired **chlorine residual**
3. The **FAC concentration** of on-site oxidants produced, which varies from site to site.

Required dosage is found by adding the oxidant demand and the desired chlorine residual. The required dosage is then divided by the FAC concentration to find the injection ratio. The water system flow rate is multiplied by the injection ratio to determine the total injection capacity.

**Example:** Site Q has a MIOX system with combined flows, producing 3400 mg/L FAC. Site Q also has a water oxidant demand of 2.0 mg/l and a desired chlorine residual of 0.5 mg/l. Thus, the total required dosage would be 2.5 mg/L (2.0 + 0.5). Site Q's water system flow rate is 3000 gph (50 gpm). What injection ratio and injection capacity does Site Q require?

1.) Divide required dosage by FAC concentration to find injection ratio:

$$\frac{2.5\text{ mg/l dosage}}{3400\text{ mg/l FAC}} = \frac{1}{1360}$$

(The injection ratio is 1:1360. This means that one part of MIOX solution needs to be injected into every 1360 parts of water to achieve the desired residual.)

2.) Multiply water system flow rate by injection ratio to find injection capacity:

$$3000\text{ gph} \times \frac{1}{1360} = 2.2\text{ gph}$$

**Oxidant Injection Capacity Required = 2.2 gph**

MIOX Corporation recommends selecting an injection system with ample oversizing in case of water oxidant demand increases, cell production capacity decreases, or a need for shocking the distribution system arises. Since chlorine production remains more or less

constant with each MIOX system, shocking the water system must be done by increasing the injection rate.

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| ***NOTE:*** **MIOX Corporation has a computer program for system sizing that also notes the necessary injection capacity. The program is available at no cost to engineering firms and distributors.** |

MIOX

# TROUBLESHOOTING/ACID WASHING CELLS

## Indication

Water with a hardness of greater than 1 grain/gallon (17.1 mg/L) feeding water to the MIOX generator will coat the plates within the cell with solid impurities such as calcium carbonate. Calcium Carbonate ($CaCO_3$) is usually white in color but can be other colors depending on dissolved salts in the water. If there is a problem, $CaCO_3$ will most likely be found in the cathode side of the cell. At first, $CaCO_3$ will form a thin hard film and over time, a coating within the cell will grow and flakes will break off and effect system performance. $CaCO_3$ will obstruct, or "blind" the current path and cause a decrease in mixed oxidant (chlorine) production. If uncorrected, the cell can be damaged.

## Actions

1.) Acid Wash the Cell according to the procedure written below.
2.) Troubleshoot to minimize reoccurrence of the problem.

Purchase and install a water softener if one is not being used. If a softener is being used, check the hardness of the water coming out of the softener. If the water is soft, put the softener into a regeneration so that it switches to the other softener tank. Check the other tank for hardness as well. If both tanks are soft, it may be possible that the salt is high in minerals or that the softener did not have a good regeneration cycle because of a brine feed blockage, low salt, check valve malfunction, etc. Monitor the softener closely. If the water from the softener is hard, check that the source water hardness has not changed, and check the regeneration cycle settings, as well as the regeneration frequency.

## Acid Washing Cell

Equipment Needed
12 inch channel lock or slip joint pliers
7/16 inch wrench, ¾ inch wrench or crescent wrench
5 gallon bucket or similar container
Latex 'acid' gloves
Face shield
Apron
Small funnel
3/8 inch tubing (6 inches)
3/8 inch push-in valve or plug
Paper towels or rags – 1 Roll
Water – 1 gal
Acid (hydrochloric acid, muriatic acid, citric acid) – 1 gal

Note: The quantity of acid and water needed will be determined by the size of the cell you are washing, what quantity of cells you are washing and how many wash cycles you perform. These quantities are examples and show the proper ratio of acid to water when mixing 37% Hydrochloric acid with water.

## Procedure

**⚠WARNING** **LOCK OUT! TAG OUT! The system must be shut down, electrically isolated and water shut off before you proceed.**

1. Step 1

Tools/Parts Required: 12" Channel Lock or slip joint pliers

- Drain the oxidant manifold piping by removing the barb fitting at the cell. Once removed, water will begin to drain from the manifold.
- Capture or soak up the drained water. Continue to do so until the manifolds are drained.

> ***NOTE:* Ensure that all spilled liquid is cleaned up immediately. The fluid can corrode electrical fittings and also leak into the transformer cabinet causing electrical problems.**

2. Step 2

- Drain the cell by opening the manual valve located on the inlet feed tubing of the cell. If there is no valve simply unplug the inlet feed tube at the plug-in fitting located on the cell. Water will begin to drain from cell and from tubing.
- Capture or soak up the drained water. Continue until all water is drained.

3. Step 3

Tools/Parts Required: 7/16 inch wrench (for SAL units and small HYPO units) or a crescent wrench; ¾ inch wrench (for Mid MIOX and Mid HYPO units), or a crescent wrench

- Remove cell leads from cell. This is done by removing the bolts that attach the leads to the cell. On SAL and small HYPO units, there are two leads, on Mid-MIOX and Mid-HYPO units there are four leads.

Step 4

Tools/Parts Required: None

- Remove cell from system.
- Place cell near a drain or a sink in a well-ventilated area with cell outlet manifolds facing up. Be sure to secure cell to prevent it from falling over and causing damage to the cell.

> ***NOTE*** the placement and orientation of the cell when removing from system to ensure it is placed back in the system in the same manner – see step **7.**

**4. Step 5**

Tools/Parts Required: 5 gallon Bucket or similar container, acid, water, latex 'acid' gloves, apron, face shield

- In a 5-gallon bucket or similar container prepare one of the following acid solution. Note: If weaker acid solutions are chosen, they are still effective. They will sufficiently clean the cell it allowed to sit longer.
  - To make a 6N HCl acid solution, add 1 part 37% hydrochloric acid into one part water.

- Muriatic acid (31% hydrochloric acid) can be mixed to make an approximate 6N HCl solution by adding 1 part muriatic acid into one part water. **This is a weaker acid solution than 6N HCl.**
- Citric acid **is a weaker acid solution than 6N HCl or 6N muriatic acid.**

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| ***NOTE:*** **Follow the manufacturer's safety precautions and procedures for handling and disposal of acid. REMEMBER – ALWAYS ADD ACID TO WATER, NEVER ADD WATER TO ACID.** |

**5. Step 6**

Tools/Parts Required: 3/8 inch tubing, push-in valve or plug, funnel, latex 'acid' gloves, safety glasses, apron, face shield

With cell outlets facing up and cell secured, proceed as follows:

- Plug the cell inlet with a piece of 3/8 tubing and a push-in valve or plug.
- Using a small funnel, pour the acid and water mixture into the cell through the cell outlets. Pour mixture into cell until cell is completely filled.
- Allow cell to sit with mixture for about 15-20 minutes (30-40 minutes if using a weaker acid solution)

| |
|---|
| ***NOTE:*** The time the cell sits with the acid/water mixture will vary depending on the type of acid solution, the amount of mineral build-up on the cell components and the particular mineral buildup being removed. When finished acid washing, properly dispose of remaining mixture. |

**Follow the manufacturer's safety precautions and procedures for handling and disposal of acid.**

- Drain cell
- Rinse cell with fresh water.

| |
|---|
| ***NOTE:*** If cell components still have a mineral build-up on them, it may be necessary to repeat appropriate portions of steps 5 and 6. |

**6. Step 7**

Place the cell in system in accordance with operations and maintenance manual. Be sure to place the cell back in the system in the same orientation as it was removed in step 4.

**7. Step 8**

Tools/Parts Required: 7/16 inch wrench (for SAL or small HYPO units) or crescent wrench, ¾" Wrench (for Mid-MIOX and HYPO units) or crescent wrench, 12 inch channel lock or slip joint pliers

When the cell has been placed back in the system, proceed as follows:

- Connect cell inlet tube.
- Connect orifice unions to cell outlet manifolds.

- Clean all leads and buss bars
- Apply a fresh coat of copper conductive grease to conducting surfaces
- Connect leads to cell with existing bolts, apply torque as follows:
    - 100 inch-pounds (11.56 Newton-Meters) for smaller systems (Sal series and small HYPO series)
    - 60 foot-pounds (81.35 Newton-Metres) for Mid-MIOX series and Mid-HYPO series
- Verify that all electrical and plumbing connections are properly connected and secure.

8. **Step 9**
    - Start the system in accordance with the operations and maintenance manual.
    - Allow the system to operate and stabilize for 15 to 20 minutes.
    - Check for leaks.

**If a system tag out was used, remove tags before starting system.**

## CELL INSTALLATION

**1. Removing old cell**

- Turn off power to the system.
- Disconnect cell leads from the buss bars.
- Remove cell from bracket, noting orientation of red and black disconnects.

**2. Installing new cell**

- Place new cell in bracket making sure red and black disconnects are oriented as before.
- Check flange nuts and buss bars for corrosion:
  - Remove outer flange nuts and buss bars, and clean or replace if corroded.
  - Check inner flange nuts and clean if corroded; tighten just past fingertight.
  - Reattach buss bars and outer flange nuts, and tighten to 75 inch-lbs.
- Inspect cell lead ends and lugs for corrosion:
  - Remove all corrosion with wire brush or sandpaper.
  - If corrosion is heavy, cut and strip jacket ends and install new lugs. MIOX recommends closed-end, copper crimp lugs with heat shrink installed to protect the wires between the wire jacket and lug.
- Connect cell electrical leads:
  - Match red lead to buss bar on side of cell with red- manifold.
  - Match black lead to buss bar on side of cell with black- manifold.
  - Tighten both connections to 75 inch-lbs. of torque.
- Check and tighten cell lead/lug flange nuts to 75 inch-lbs. torque.

**3. Check Cell Operation**—*Perform checks frequently for first 2 weeks, and then weekly thereafter.*

- Check temperature of cell buss bars:
  - Less than 85 °F (warm to touch) is normal.
  - Greater than 85 °F (hot to touch) indicates corrosion or loose connections.
    - Shut down system and repair.
    - Contact distributor if problem persists.
- Tighten outer flange nuts on the buss bars to 75 inch-lbs.
- Tighten cell lead connection to 75 inch-lbs.
- Tighten cell perimeter bolts to 50 inch-lbs.
- Repair/replace parts if leaking.

**4. Returning the old cell**

- Contact MIOX Corporation Customer Service to obtain a return merchandise authorization (RMA) number.
- Pack cell in original packing materials or an appropriate substitute to prevent damage during shipping.
- Note the installation site name, system serial number, and number of hours the cell has been used. Enclose this information with the cell.
- Send the package freight prepaid to:

  MIOX Corporation<br>
  ATTN: Customer Service<br>
  5601 Balloon Fiesta Parkway NE<br>
  Albuquerque, NM 87113

Please call your MIOX distributor for questions regarding service or cell replacement.

## BRINE PUMP

MIOX SAL system brine pumps are 24 VDC magnetically driven gear pumps. The rotation speed of the gears, and thus the pump flow, is controlled by a 0 to 5 VDC signal. Unless there is a catastrophic failure, these pumps should last for thousands of hours.

Check the following items to determine why the pump is not operating:

**Air Lock**

The brine pump tubing can sometimes develop an air lock (especially on initial start-up) that does not allow the flow of brine to the brine pump. The pump will usually overcome this air lock, but it is often quicker to help prime the pump. To prime the pump, either loosen a tube fitting so that air escapes or add water to the tubing. In extreme cases, disconnect one of the solenoid wires (pin 12 or 13) while the MIOX system is running. This will stop water flow and allow the pump to prime itself.

**Improper Wiring**

Check that the wiring is correct and that the connectors pinch the metal wire and not the plastic protective sleeve:

- White or Clear (Pump Control Voltage) to connector 21
- Black (Return Voltage) to connector 23
- Green or Bare (Pump Tach Output) to connector 26 *(May not be present since Tach is not monitored)*
- Red (Positive 24 VDC) to connector block opposite of Red Wire
- Bare not used *(May not be present)*.

**Water Damage of the Magnet**

Remove the six screws that hold the pump head flange on to the magnet assembly. Visually inspect the magnet for corrosion and water damage. If corrosion is present, the pump is likely damaged or will soon be damaged and needs to be replaced. Determine how water and/or salt is entering the magnet area and correct to prevent damage in the future.

***NOTE:* Brine pumps are splash proof, but not water proof. Do not allow the pump to become wet from leaks, salt creep, hosedowns or other actions that might allow water near the pump.**

**Salt Accumulation**

If the system has been idle for an extended period of time dried salt can accumulate on the internal gears. To clean the pump, remove it from the system and run fresh water through the pump head for 5 minutes. Retry the pump operation. If salt accumulation is visible on the outside of the pump, the threaded fittings on the inlet and/or outlet of the pump head are not sealing properly. Remove the fittings and any excess Spears blue 75 thread sealant. Reapply two or three wraps of Spears blue 75 thread sealant to the threads

of the fitting, but be sure that the last thread (first thread inserted) is free of Spears blue 75 thread sealant.

**⚠WARNING Be SURE not to get Spears blue 75 thread sealant or pipe compound on the end of the fitting to avoid any material entering the pump gears.**

Reinstall both fittings in the pump head, making sure that the check valve fitting is on the discharge end of the pump and secure tightly. If necessary, return the pump to Miox Corporation for evaluation and repair.

# FLOAT VALVE

## Introduction

In early 1998, MIOX revised the float valve configuration to use a National 400 float valve that is sold for replacements in toilet tanks (commodes). These valves are designed to operate at 300 psi for 2,000,000 cycles. They have proven to be reliable when there is no physical binding of the float mechanism. Top and bottom centering guides are incorporated in the design to ensure that the float mechanism is free from obstruction. A special adapter has also been incorporated in the design to ensure that the O-ring seal at the bottom of the valve is installed and seals properly. The float valve assembly is shown in Figure 16. This assembly is designed to slide into the 4" PVC pipe stillwell. Generally speaking, the only fluid in the stillwell is clean water.

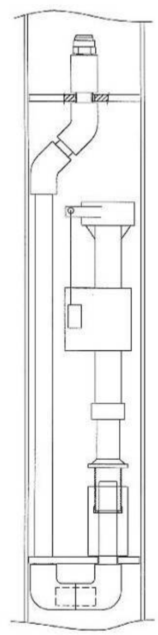


**Figure 16. Float Valve Assembly**

## Troubleshooting

There are situations where an overflow in the brine tank is falsely associated with the float valve. Double check that water is not getting into the brine tank due to:

1) A plugged drain line, frequently caused when the overflow line to the brine generator is connected with the drain line to the water softener. This configuration could allow water discharged from the softener to back up to the brine generator tank through the overflow port.
2) A malfunctioning check valve. The line between the brine tank and water softener may not have a check valve, or the check valve may be installed backwards. The check valve must allow brine to flow to the softener, but not allow flow from the softener back to the brine generator.

## Procedure

Before proceeding, turn off the water to the system. To remove the valve assembly, disconnect the union fitting(s) above the 4" PVC pipe cap and slide the assembly (with the 4" pipe cap) out of the pipe. Do not pull up on or allow the 4" pipe to come out of the brine generator, particularly if there is salt in the brine generator. If the pipe is removed, it will be difficult to get it back into the brine generator without first removing the salt.

To check the float valve assembly for leaks, reconnect the float valve assembly to the union fittings with the float valve outside of the 4" pipe. Gently slide the float up on the stem until it stops. While holding the float up in the shut-off position, turn on the main water supply and

check the valve and fittings for leaks. Gently move the float valve up and down to be sure it is shutting off the water properly.

**⚠CAUTION Avoid excess water spray to surrounding equipment.**

If the assembly is leaking at one of the glue joints, perform field repairs with 3/8" schedule 80 PVC pipe and fittings. If a threaded joint is leaking, re-coat with Spears blue 75 thread sealant (or equivalent) and re-tighten the joint. Recheck for leaks.

**⚠CAUTION Do not allow Spears blue 75 thread sealant or pipe joint compound to get inside the fittings or valves.**

If the float valve is leaking or fails to shut off, disassemble the valve to clear the source of obstruction or replace the float valve. The float valve can be disassembled without tools. If the valve is to be replaced, a replacement unit can be obtained through your MIOX distributor or hardware, builder's supply, or plumbing stores. The float valve is screwed on to an adapter bushing that is custom made for this application. If replacing the valve, it may not be necessary to replace the O-ring that is in the bottom of the bore in the adapter fitting even though a new O-ring is typically included with each float valve. The O-ring will be difficult to remove from the bore of the adapter fitting, since the O-ring is about 1" down in the bottom of the annular space between the threads of the adapter fitting and the outside of the 3/8" diameter pipe stem, which is sticking up out of the adapter. If the O-ring requires replacement, it will have to be fished out with a piece of wire or paperclip with a hook on the end. When re-installing the float valve on the pipe assembly, re-install an O-ring (if required) and screw the float valve all the way to the bottom of the bore in the adapter fitting since the O-ring will provide the seal at the bottom of the bore.

If the assembly is checked and has no leaks, the only other problem can be binding of the float or float lever arm in the bore of the 4" PVC stillwell after the assembly is installed in the pipe. The assembly has centering guides at the top and bottom to hold it in the center of the pipe. The plumbing coming out of the bottom of the float valve adapter spool and then turning up and going over the top of the float valve is 3/8" schedule 80 PVC pipe. Alignment of the float on the valve with the 3/8" side pipe in the plumbing is critical to avoid binding of the float to the 3/8" pipe or the inside wall of the 4" PVC pipe stillwell. The float valve mechanism itself is designed to be adjustable in height and orientation of the float mechanism with respect to the center of the float valve. The inner and outer pipe stem on the float valve is designed to screw and unscrew to extend or shorten the overall length of the float valve. Rotate the upper section of the float valve with respect to the lower section so that the float is next to the 3/8" riser pipe. Refer to *Figure 17*. However, the float must not be allowed to touch the 3/8" riser pipe even when the assembly is lying on its side. Aligning the float next to the 3/8" riser pipe will ensure that the float does not hang up on the inside wall of the 4" PVC stillwell pipe. Re-connect the float valve to the water source and check for leaks.

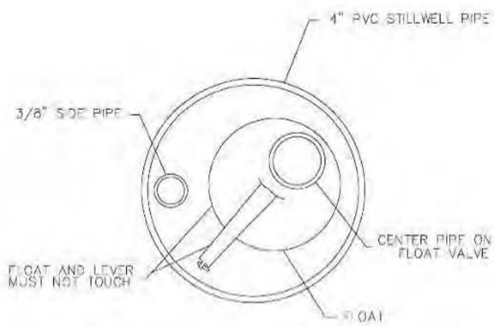



**Figure 17. Section through Center of Float Valve**

Slide the float valve assembly into the 4" PVC pipe and visually verify that no part of the float valve or lever arm hangs up on the inside wall of the 4" pipe. Reconnect water and check for proper operation.

## SOLENOID

The solenoid *(Figure 18)* has a 1/8" orifice and is normally closed. It is located on the pipe manifold just next to the PRV. It has a brass body with a black electrical coil with two lead wires going to the junction box. Its function is to turn the water flow on and off to the system. On occasion, the solenoid can become plugged with debris and will not close properly. Follow these directions to disassemble and clean the solenoid.

1. Turn off the system and close the water supply valve.
2. Remove the top nut that holds the black electronics portion on to the stem. Place the electronics portion aside.
3. Hold the valve body firmly with a wrench to avoid damage to pipe fittings. Apply another wrench directly to the hex flange to loosen the sleeve assembly. Once it is loosened, the plunger and return spring can be removed. Inspect plunger and orifice for debris.
4. Clean all parts (excluding the black electrical portion) with mild soap and water solution.
5. To reassemble the parts, please refer to the drawing below. All parts must be replaced in the order shown on the drawing.
6. For reference, the orientation of the solenoid is important. The direction of flow through the valve goes **in** the port stamped with a "1" and comes **out** the port stamped with a "2."

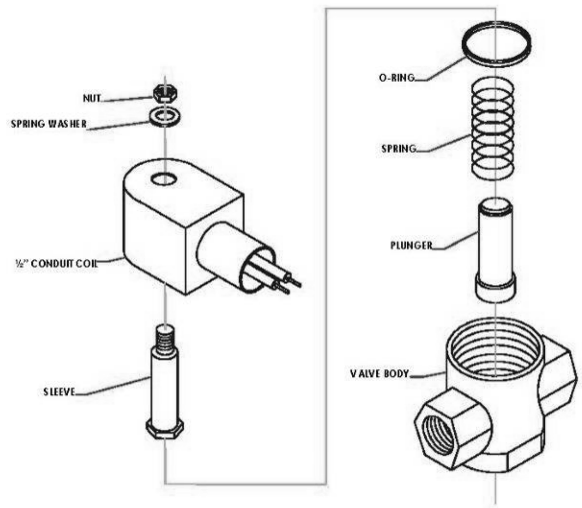



Figure 18. Solenoid

MIOX

## LEVEL SWITCH

The level switch measures the level of on-site oxidants in the solution tank, signaling to the MIOX system when to resume production of on-site oxidants and when to cease production of on-site oxidants and go into standby. The switch functions with an upper float, which indicates a full tank, and a lower float, which indicates low level. When the oxidant solution tank is dry, the switch is Normally Closed (NC) with both floats in the down position. Within each float is a reed switch to signal the MIOX system. Operation of the level switch can easily be checked with a multimeter that has continuity or resistance (ohms).

### Checking Operation

Before checking the electrical circuit, visually inspect the level switch for build-up or blockage that might be preventing proper motion of the floats. Also verify that the floats are properly limited in motion (should not move more than 0.5 inches). Next, locate the three wires coming out of the top of the level switch, and verify that all are corrosion-free:

- Black – Common
- Red – Bottom Switch
- White – Top Switch.

To check electrical function, the probes of the multimeter can be touched either to the connector pins in the junction box or directly to the level switch wires, after disconnecting the wires from the junction box.

***Bottom Switch:***

To measure the circuit for the bottom switch, touch the black probe of the multimeter to the black wire on the level switch, and touch the red probe of the multimeter to the red wire on the level switch. The circuit should be closed when the bottom switch is down, regardless of the position of the top switch. To create an open circuit, toggle the bottom switch to the up position. Again, toggling the top switch should not affect the circuit.

***Top Switch:***

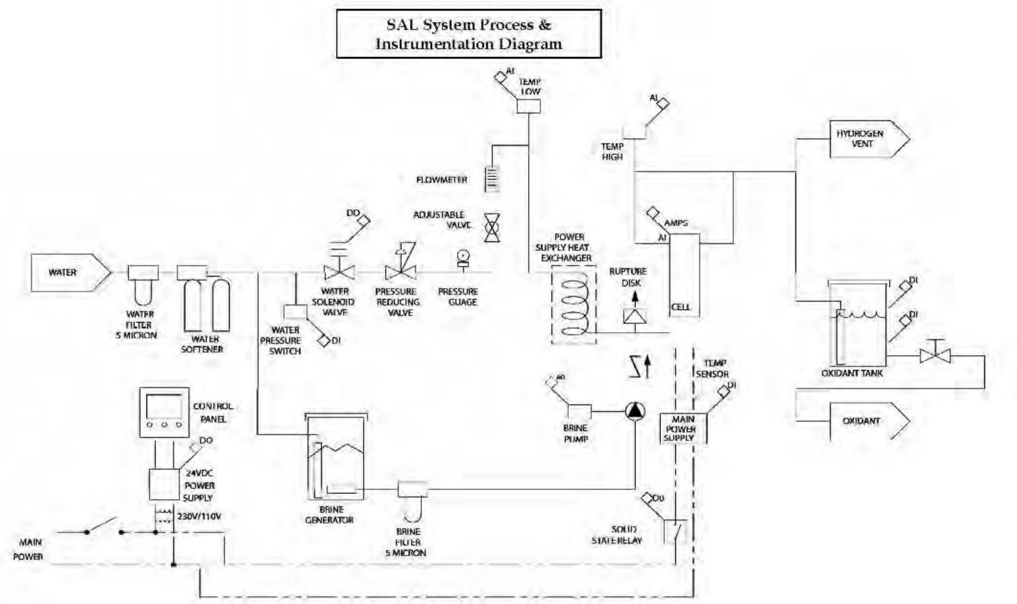
Continue touching the black probe to the black wire, and move the red probe of the multimeter to the white wire of the level switch. The circuit should be closed when the top switch is down, regardless of the position of the bottom switch. To create an open circuit, toggle the top switch to the up position. Again, toggling the bottom switch should not affect the circuit.

If the multimeter does not indicate a closed circuit when the instructions above are followed, the level switch is damaged. Contact your representative for a new level switch.

| | | | | |
|---|---|---|---|---|
| Top Switch: | Closed (↓) | Closed (↓) | Open (↑) | Open (↑) |
| Bottom Switch: | Closed (↓) | Open (↑) | Closed (↓) | Open (↑) |
| **MIOX System** | Tank is dry (system | Tank is filling (system is operating) | System fault | System is in standby |

| | | | | |
|---|---|---|---|---|
| Top Switch:<br>Bottom Switch: | Closed (↓)<br>Closed (↓) | Closed (↓)<br>Open (↑) | Open (↑)<br>Closed (↓) | Open (↑)<br>Open (↑) |
| **Interpretation:** | will begin operation) | or is in standby (tank is being drained) | (impossible configuration) | (tank just filled and is starting to drain) |

# *Appendix E – SYSTEM PROCESS, INSTRUMENT, AND ELECTRICAL SCHEMATICS*


SAL System Process & Instrumentation Diagram
AI
TEMP LOW
FLOWMETER
ADJUSTABLE VALVE
DO
WATER
WATER FILTER 5 MICRON
WATER SOFTENER
WATER SOLENOID VALVE
PRESSURE REDUCING VALVE
PRESSURE GUAGE
WATER PRESSURE SWITCH
DI
CONTROL PANEL
DO
24VDC POWER SUPPLY
230V/110V
MAIN POWER
BRINE GENERATOR
BRINE FILTER 5 MICRON
AI
TEMP HIGH
HYDROGEN VENT
AMPS
AI
POWER SUPPLY HEAT EXCHANGER
RUPTURE DISK
CELL
DI
DI
OXIDANT TANK
OXIDANT
TEMP SENSOR
DI
AO
BRINE PUMP
MAIN POWER SUPPLY
DO
SOLID STATE RELAY

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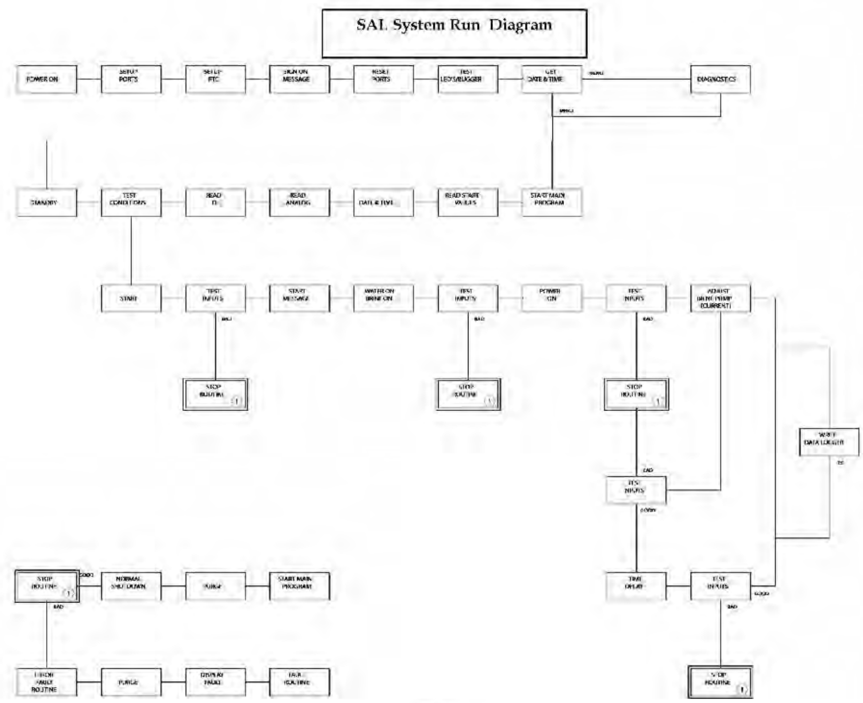
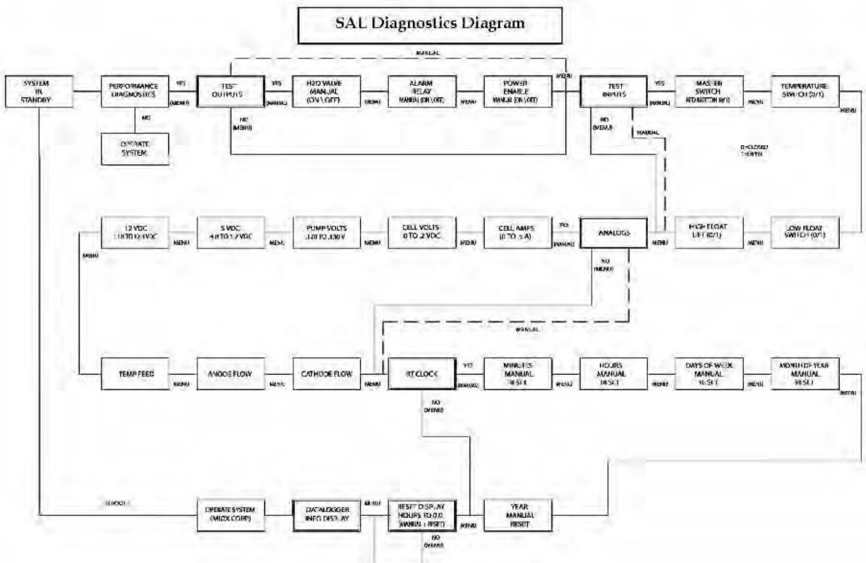
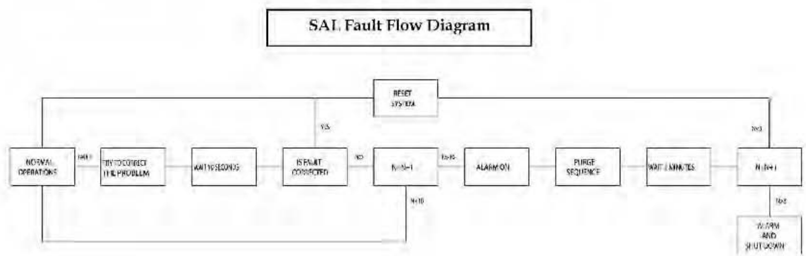

SAL System Run Diagram
POWER ON
SIGN ON MESSAGE
RESET PORTS
GET DATE & TIME
DIAGNOSTICS
STANDBY
TEST CONDITIONS
READ ANALOG
READ START VALUES
START MAIN PROGRAM
START
TEST INPUTS
START MESSAGE
WATER ON BRINE ON
POWER ON
ADJUST BRINE PUMP (CURRENT)
BAD
STOP ROUTINE
WRITE DATA LOGGER
GOOD
TIME DELAY
NORMAL SHUT DOWN
PURGE
ERROR FAULT ROUTINE
DISPLAY FAULT
EXIT ROUTINE

99


SAL Diagnostics Diagram
SYSTEM IN STANDBY
PERFORMANCE DIAGNOSTICS
OPERATE SYSTEM
TEST OUTPUTS
H2O VALVE MANUAL (ON \ OFF)
ALARM RELAY
POWER ENABLE
TEST INPUTS
MASTER SWITCH
TEMPERATURE SWITCH (0/1)
ANALOGS
CELL VOLTS 0 TO 2 VDC
PUMP VOLTS
5 VDC
12 VDC
LOW FLOAT SWITCH
HIGH FLOAT
TEMP FEED
ANODE FLOW
CATHODE FLOW
RT CLOCK
MINUTES MANUAL RESET
HOURS MANUAL RESET
DAYS OF WEEK MANUAL RESET
MONTH OF YEAR MANUAL RESET
YEAR MANUAL RESET
RESET DISPLAY HOURS TO 0.0
DATALOGGER INFO DISPLAY
OPERATE SYSTEM
MANUAL
MENU
YES
NO


SAL Fault Flow Diagram
RESET SYSTEM
YES
NORMAL OPERATIONS
TRY TO CORRECT THE PROBLEM
IS FAULT CORRECTED
NO
ALARM ON
PURGE SEQUENCE
ALARM AND SHUTDOWN

# *Appendix F – MATERIAL SAFETY DATA SHEETS (MSDS)*

# MATERIAL SAFETY DATA SHEET

IDENTITY (As Used on Label and List)
**MIOX Combined Anolyte and Catholyte Solutions**

Note: Blank spaces are not permitted if any item is not applicable, or no information is available. The space must be marked to indicate that.

## Section I

| | |
|---|---|
| Manufacturer's Name<br>**MIOX Corporation** | Emergency Telephone Number<br>**1-505-343-0090** |
| Address (Number, Street, City, State, and Zip Code)<br>**5601 Balloon Fiesta Parkway**<br>**Albuquerque, NM 87113** | Telephone Number for Information<br>**1-505-343-0090** |
| | Date Prepared<br>**May 11, 2006** |
| | Signature of Preparer (Optional) |

## Section II.a- Hazardous Ingredients/Identity Information (Mixed Oxidants)

Hazardous Components (Source Chemical Identity: Common Name(s))

| | Concentrations in mg/L | | | | | | | | | OSHA PEL | ACGIH | Other Names |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MIOX Unit | BPS/P3 | SAL-30 | SAL-40 | SAL-80 | M-25N | M-50N | M-100N | M-250N | M-500N | | | |
| MIOX Cell Size | C5 | C30 | C40 | C80 | C25 | C50 | C100 | C250 | C500 | mg/m³ | TLV | Recommended |
| $Cl_2$/HOCl/OCl⁻ Chlorine gas/Hypochlorous acid/Hypochlorite Ion (as $Cl_2$ equivalent) | 400 | 2700 | 2800 | 3400 | 4000 | 4000 | 4000 | 4000 | 4000 | 0.5 | N/A | N/A |
| $H_2$ Hydrogen Gas dissolved in solution | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | N/A | N/A | N/A |
| NaOH Sodium Hydroxide (pH < 10.0) | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | N/A | N/A | pH<12.5† |
| $H_2$ Hydrogen Gas Rate (mL/min) at STP § | 77 | 488 | 627 | 1,253 | 3,758 | 6,264 | 12,528 | 43,848 | 87,696 | N/A | N/A | N/A |

*Gas phase limit for chlorine gas. Also see Section IV below. †RCRA characteristics of corrosivity in solution.

The MIOX anolyte and catholyte solutions are generated electrolytically from a sodium chloride brine. The mixed-oxidant solution made by combining the anolyte and catholyte solutions contains several chemical components which are either dissolved completely or are in dynamic equilibrium with the overlying gas phase.
Hazards are associated largely with the gases that may evolve from the solution. At the operational pH of the combined solution, dissolved $Cl_2$ gas is completely hydrolyzed to the forms HOCl and $OCl^-$; thus $Cl_2$ gas evolution is minimal.
The pH of combined anolyte and catholyte from all cells is pH < 10.0 (usually < 9.0). The NaOH concentration in these solutions is nominally < 4 mg/L. § STP is 0C and 1 atmosphere. Gas rate increases proportional to the absolute temperature and inverse to barometric pressure.
* Extrapolated from Fang, et.al., 2002, Wat. Res., 36(14):3533-3542.

## Section II.b - Hazardous Ingredients/Identity Information (Hypochlorite)

Hazardous Components (Source Chemical Identity: Common Name(s))

| | Concentrations in mg/L | | | | | | | | | OSHA PEL | ACGIH | Other Names |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| HYPO Unit | | HYPO-5 | HYPO-10 | HYPO-20 | H-50N | H-100N | H-200N | H-500N | H-1000N | | | |
| HYPO Cell Size | | HC5 | HC10 | HC20 | HC50 | HC100 | HC200 | HC500 | HC1000 | mg/m³* | TLV | Recommended |
| $Cl_2$/HOCl/OCl⁻ | | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 8000 | 0.5 | N/A | N/A |
| $H_2$ Hydrogen Gas dissolved in solution | | 8 | 8 | 8 | 8 | 8 | 8 | 8 | 8 | N/A | N/A | N/A |
| NaOH Sodium Hydroxide (pH < 10.0) | | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | < 5 | N/A | N/A | pH<12.5† |
| $H_2$ Hydrogen Gas Rate (mL/min) at STP § | | 1,462 | 1,880 | 3,759 | 11,276 | 18,792 | 37,584 | 87,696 | 175,392 | N/A | N/A | N/A |

*Gas phase limit for chlorine gas. Also see Section IV below. †RCRA characteristics of corrosivity in solution.

The MIOX hypochlorite solution is generated electrolytically from a sodium chloride brine. The hypochlorite solution contains several chemical components which are either dissolved completely or are in dynamic equilibrium with the overlying gas phase.
Hazards are associated largely with the gases that may evolve from the solution. At the operational pH of the solution, dissolved $Cl_2$ gas is completely hydrolyzed to the forms HOCl and $OCl^-$; thus $Cl_2$ gas evolution is minimal.
The pH of the solution from all cells is pH < 10.0 (usually < 9.0). The NaOH concentration in these solutions is nominally < 4 mg/L.
§ STP is 0C and 1 atmosphere. Gas rate increases proportional to the absolute temperature and inverse to barometric pressure.
* Extrapolated from Fang, et.al., 2002, Wat. Res., 36(14):3533-3542.

## Section III - Physical/Chemical Characteristics

| | | | |
|---|---|---|---|
| Boiling Point | 100° C | Specific Gravity ($H_2O$= 1) | 1.03 |
| Vapor Pressure (mm Hg) | N/A | Melting Point | 0° C |
| Vapor Density (AIR = 1) | N/A | Evaporation Rate (Butyl Acetate =1) | N/A |

Solubility in Water: **Completely Soluble.**
Appearance and Odor: **Clear Liquid. Mild Caustic Odor.**

**MIOX Combined Anolyte and Catholyte Solutions and Hypochlorite solution continued...**

## Section IV - Fire and Explosive Hazard Data

| Flash Point (Method Used) | Flammable Limits | LEL* | UEL* |
|---|---|---|---|
| **None** | **None** | **4.1% ($H_2$)** | **74.2% ($H_2$)** |

| | |
|---|---|
| Extinguishing Media | **N/A** |
| Special Fire Fighting Procedures | **No special procedures required.** |

*Lower and Upper Explosive Limits from N. Irving Sax, Dangerous Properties of Industrial Materials, 5th ed. Van Nostrand Reinhold Co., NY 1979

Unusual Fire and Explosion Hazards
**Hydrogen buildup can occur in a tightly sealed, unventilated enclosure. Sparks, open flames, smoking, and other sources of ignition should be avoided when MIOX systems are in operation. Ensure compliance with local and national building, electrical, and safety codes.**

## Section V - Reactivity Data

| Stability | Unstable<br>Stable | <br>X | Conditions to Avoid |
|---|---|---|---|

Incompatibility (Materials to Avoid)
**No Vapor incompatibilities.**

| Hazardous Decomposition or By-products | May Occur<br>Will Not Occur | <br>X | Conditions to Avoid |
|---|---|---|---|
| **None** | | | |

## Section VI - Health Hazard Data

| Route(s) of Entry: | Inhalation? | Skin? | Ingestions? |
|---|---|---|---|
| | X | X | X |

Health Hazards (Acute and Chronic)
**Inhalation of hydrogen gas causes no symptoms (the primary hazard from hydrogen gas is explosions.) Exposure to combined solution causes minor skin or eye irritation. Ingestion causes vomiting and gastric distress.**

| Carcinogenicity | NTP? | IARC Monographs? | OSHA Regulated |
|---|---|---|---|

**None- No components are known carcinogens.**

Signs and Symptoms of Exposure
**Exposure to skin causes mild irritation. Ingestion causes vomiting.**

Medical Conditions
Generally Aggravated by Exposure **Dermatitis**

Emergency and First Aid Procedures
**Wash immediately if skin, eyes, or mouth are exposed to solution.**
**Induce vomiting if solution is ingested.**

## Section VII - Precautions for Safe Handling and Use

Steps to be taken in case material is released or spilled: **Flush spill area with clean water.**

Waste Disposal Method: **Sanitary or storm sewer.**

Precautions to be taken for handling and storing: **No special precautions required.**

Other Precautions: **MIOX production area must be well-ventilated to prevent hydrogen gas accumulation. Ensure compliance with local and national building, electrical, and safety codes.**

## Section VIII - Control Measures

Respiratory Protection (Specify Type)
**None required.**

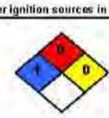
| Ventilation | Local Exhaust<br>Mechanical (General) | **Normal room ventilation**<br>**Normal room ventilation** | Special<br>Other | **Not required**<br>**N/A** |
|---|---|---|---|---|

| Protective Clothing/Gloves | Eye Protection |
|---|---|
| **Rubber gloves advised** | **Goggles Advised** |

Other Protective Clothing or Equipment
**None**

Work/Hygienic Practices
**Avoid open flames, sparks, smoking and other ignition sources in the vicinity of MIOX systems and associated equipment.**

NFPA Placard



**Clockwise from Left:**
Health = 1
Flammability = 0
Reactivity = 0
Other Specific Hazard = Null

# Index

**MIOX Corporation**
Customer Service Dept.
5601Balloon Fiesta Parkway NE
Albuquerque, NM 87113
Phone: 505.343.0090
Toll Fee: 1.866.MIOX.HLP (1.866.646.9457)
FAX: 505.343.0093
CustSvc@miox.com
www.miox.com

*For general information and customer support, please contact your sales agent distributor or MIOX Corporation Customer Support.*

***International distributors and sales agents located worldwide***

# ATTACHMENT 2
# SURTECH SAFETY POLICY
# SURTECH CORPORATION SAFETY POLICY

*SurTech Corporation is in the business of manufacturing, selling, and servicing in the water treatment chemical business. Our first and foremost concern shall be for the safety of our customers and their employees. Even though many of our products may be safely added to drinking water or be used under USDA or FDA guidelines in customer facilities, they can be hazardous in their concentrated form.* **ALL PEOPLE WHO HANDLE AND WORK WITH SURTECH CORPORATION'S PRODUCTS WILL BE TRAINED IN THEIR SAFE USE.** *This document provides information and guidance for the establishment and maintenance of an accident-free work environment.*

Any injury resulting from the use or handling of our products or any adverse reaction must be reported to our corporate office within one business day.

PLANT SAFETY PROCEDURES FOR SURTECH EMPLOYEES AND CONTRACTORS

## GENERAL INFORMATION:

A copy of the following documents will be maintained on each job site:

SurTech Corporation Safety Manual

OSHA Safety and Health Standards (29 CFR 1926 – Construction and 29 CFR 1910 – General Industry)

## SAFETY AND HEALTH POLICY:

The purpose of this policy is to develop a high standard of safety throughout all operations of SurTech Corporation and to provide guidelines so employees are not required to work under conditions that are hazardous or unsanitary. Employees have the right to derive personal satisfaction from their jobs. The prevention of occupational injury or illness is central to this belief that it will be given top priority at all times. It is SurTech Corporation's goal to initiate and maintain complete accident prevention

and safety training programs. Each individual is responsible for the safety and health of those persons in their charge and co-workers around them. By accepting mutual responsibility to operate safely, we will all contribute to the well being of personnel.

**SAFETY AND HEALTH RESPONSIBILITIES:**

**SUPERVISORS AND MANAGERS:**

The safety and health of the employees they supervise is a primary responsibility of supervisors and managers.. To accomplish this obligation, supervisors will:

- Conduct pre-job safety orientations with all workers to outline safety and health rules, regulations and policies. Review rules as the job or conditions change or as required.
- Require the proper care and use of all required protective equipment.
- Identify and eliminate job hazards through job safety analysis procedures.
- Inform and train all employees on the hazardous chemicals they MAY encounter under normal working conditions or during an emergency situation.
- Receive and take initial action on employee suggestions, awards or disciplinary measures.
- Train all employees in the safe and efficient methods of accomplishing each job or task.

**EMPLOYEE SAFETY AND HEALTH RESPONSIBILITIES**

- Report all on the job injuries promptly.
- Report all equipment damage to your supervisor immediately.
- Don’t take chances – use your safety equipment as directed.
- Follow instructions – ask questions of your supervisor if required.
- Observe and comply with all safety signs and regulations.
- Report all unsafe conditions or situations that are potentially hazardous.
- Operate only equipment you are qualified to operate. When in doubt, ask for directions.
- Talk to management about problems that affect your safety or work conditions.

The most important part of this program is the individual employee – You! Without your cooperation, the most stringent program can be ineffective. Protect yourself and your fellow worker by following the rules. Remember: Work safely so you can go home to your family and friends.

**Don't take chances – THINK SAFETY FIRST!**

## GENERAL SAFETY RULES

- Always store materials in a safe manner. Tie down or support piles if necessary to prevent falling, rolling or shifting.
- Fall protection gear shall be used whenever working at 6 feet or hight above the ground/floor in a space that is not properly pretected by guardrails and kick plates. If in question, review situation with Supervisor before proceeding with work.
- Shavings, dust, scraps, oil or grease should not be allowed to accumulate. Good housekeeping is a part of the job.
- Refuse piles must be removed as soon as possible. Refuse is a safety and fire hazard.
- Remove or clinch nails in lumber that has been used or removed from a structure.
- Immediately remove all loose materials from stairs, walkways, ramps, platforms, etc.
- Do not block aisles, traffic lanes, fire exits, gangways or stairs.
- Avoid shortcuts – use ramps, stairs, walkways, ladders, etc.
- Standard guardrails must be erected around all floor openings and excavations must be barricaded. Contact your supervisor for the correct specifications.
- Get help with heavy or bulky materials to avoid injury to you or damage to material.
- Keep all tools and materials away from the edges of scaffolding, platforms, shaft openings, etc.
- Do not use tools with split, broken or loose handles, burred or mushroomed heads.
- Keep cutting tools sharp and carry all tools in a container.
- Know the correct use of hand and power tools. Use the right tool for the job.
- All electrical power tools (unless double insulated), extension cords and equipment shall be properly grounded.

- All electrical power tools and extension cords shall be properly insulated.
- Damaged cords shall be replaced.
- Know the location/use of fire extinguishing equipment and the procedure for sounding an alarm.
- Flammable liquids shall be used only in small amounts at the work site, in approved safety cans.
- Proper guards or shields must be installed on all power tools before use. Do not use any tools without the guards in their proper working condition. No “homemade” handles or extensions (cheaters) will be used!
- Do not operate any power tool or equipment unless you are trained in its operation and authorized by your firm to do so.
- Use tools only for their designed purpose.
- Do not remove, deface or destroy any warning, danger sign or barricade, or interfere with any form of accident prevention device or practice provided for your use or that is being used by other workmen.
- All electrical power equipment and tools must be grounded or double insulated.
- Use tools only for their designed purpose.

## LADDER SAFETY RULES

### GENERAL

- Inspect for physical defects before use.
- Ladders are not to be painted except for numbering purposes.
- Do not use ladders for skids, braces, workbenches or any purpose other than climbing.
- When you are ascending or descending a ladder, do not carry objects that will prevent you from grasping the ladder with both hands.
- Always face the ladder when ascending or descending.
- If you must place a ladder over a doorway, barricade the door to prevent its use and post a warning sign.
- Only one person is allowed on a ladder at a time.
- Always keep both feet on the ladder rungs. Do not step laterally from a ladder onto another object.
- Do not jump from a ladder when descending.
- All joints between steps, rungs and side rails shall be tight.
- Safety feet shall be in good working order and in place.

- Rungs shall be free of grease and/or oil.
- Fall protection gear shall be used whenever working at 6 feet or hight above the ground/floor in a space that is not properly protected by guardrails and kick plates. If in question, review situation with Supervisor before proceeding with work.

## STRAIGHT TYPE OR EXTENSION LADDERS

- All straight or extension ladders must be at least three feet beyond the supporting object when used as an access to an elevated work area.
- After raising the extension portion of a two or more stage ladders to the desired height, check to be sure that the safety dogs or latches are engaged.
- All extension or straight ladders must be secured or tied off at the top.
- All ladders must be equipped with safety (non-skid) feet.
- Portable ladders shall be used at such a pitch that the horizontal distance from the top support to the foot of the ladder is about one-quarter of the working length of the ladder.

## STEPLADDERS

- Do not place tools or materials on the steps or platform of a stepladder.
- Do not use the top two steps or ladder cap of a stepladder as a step or stand.
- Always level all four feet and lock spreaders in place.
- Do not use a stepladder as a straight ladder.
- All ladders must be equipped with safety (non-skid) feet.
- Portable ladders must be used at such a pitch that the horizontal distance from the top support to the foot of the ladder is about one-quarter of the working length of the ladder.

## MOTORIZED VEHICLES AND EQUIPMENT SAFETY RULES

- Do not ride on motorized vehicles or equipment unless a proper seat is provided for each rider.
- Always be seated when riding authorized vehicles (unless they are designed for standing.)
- Always use your seat belts in the correct manner.
- Obey all speed limits and other traffic regulations.
- Always be aware of pedestrians and give them the right-of-way.

- Always inspect your vehicle or equipment before and after daily use.
- Never mount or dismount vehicles or equipment while they are still in motion.
- Do not dismount any vehicle without first shutting down the engine, setting the parking brake, and securing the load.
- Do not allow other persons to ride the hook or block, dump box, forks, bucket, or shovel of any equipment.
- Each operator must be knowledgeable of all hand signals and obey them. Any equipment used on site needing communication with another for operation – all parities operating the equipment to review the hand signals to be used and meanings of each prior to using the equipment
- Each operator is responsible for the stability and security of their load.

## FIRST AID PROCEDURES IN CONSTRUCTION

First aid at the job site is done on a Good Samaritan basis. If employees are involved in a situation involving blood, they should:

- Avoid skin contact with blood/OPIM (other potentially infectious materials) by letting the victim help as much as possible, and using gloves provided in first aid kit.
- Remove clothing, etc., with blood on it after rendering help.
- Wash thoroughly with soap and water to remove blood. A 10% chlorine bleach solution is good for disinfecting the area contaminated with blood (spills, etc.).
- Report such first aid incidents within the shift to supervisors (time, date, blood presence, exposure, those helping).

The employee should receive full Hepatitis B vaccinations as soon as possible, but no later than 24 hours, after the first aid incident. If an exposure incident occurs, the following steps should be followed: a post exposure evaluation, follow-up treatment, follow-up as listed in CDC guidelines.

Training covering the above information should be conducted at job site safety meetings.

## PROCEDURE FOR INJURY OR ILLNESS ON THE JOB

Owner or supervisor shall immediately take charge:

- Call 911 EMS.
- Render Good Samaritan first aid, if possible by a first aid certified employee.
- Arrange for transportation (ambulance, helicopter, company vehicle, etc.), depending on seriousness.
- Notify top management if not already present. Superintendent and/or Project Administrative Assistant.
- Do not move anything unless necessary, pending investigation of accident.
- Accompany or take injured person to doctor, hospital, home, etc. (depending on extent of injuries).
- Take injured person to family doctor if available.
- Remain with injured until relieved.

When the injured person's immediate family is known by the management or supervisor, they should properly notify these people, preferably in person, or have an appropriate person do so.

## ENERGY CONTROL (LOCKOUT/TAGOUT)

SAFE CLEARANCE AND LOCKOUT/TAGOUT PROCEDURES

The basic safety rule governing safe clearance and lockout/tagout procedures is that all conductors and equipment are considered energized until all sources of electrical energy have been disconnected or otherwise prevented from energizing the equipment or circuits being worked on. Even with safe clearance and lockout/tagout procedures applied, all lines and apparatus must be grounded with approved grounding methods and tested for no voltage. This will reduce the voltage across the worker to the lowest

practical value possible, in case the line or equipment being worked on is accidentally energized. As part of safe working practices, the lockout/tagout process requires a circuit be de-energized, tested dead, isolated, tested dead, locked out, tagged, and grounded.

CONSTRUCTION ELECTRICAL SAFETY

*GROUND FAULT PROTECTION*

Electrical hazards are a significant source of injuries and fatalities in the construction industry. Employee contact with electricity is responsible for approximately 18% of the fatalities observed in construction. Many injuries and fatalities could be prevented through the use of safe electrical work practices that include providing ground fault circuit interrupters on all temporary wiring.

All electrical work will be in accordance with the Department of Defense United Facilities Criteria Electric Safety, O & M UFC 3-560-1, 6 December 2006.

All employers on construction sites are required to use either ground fault circuit interrupters (GFCI) or assured equipment grounding conductor programs to protect employees from the risk of electrocution or shock. There are several different means of employing GFCI depending on the application: A. as an attachment to an appliance cord, B. installed at the breaker panel, or C. provided at the receptacle.

Extension cords are considered to be temporary wiring; therefore, you should ensure that ground fault protection is used in conjunction with all extension cords on construction sites.

All apparel, tools, and equipment used on the job must comply with UFC 3-560-1 as well as the applicable services and OSHA requirements. Regular inspections are also necessary to prevent the use of defective items on the job. The authorized individual-in-charge may, regardless of ownership, prohibit the use of any equipment on the job which could be considered unsafe.

An initial inspection of tools brought on the job by a new worker must be made by the authorized individual-in-charge. Use must be permitted only if the tools are in good condition and conform to requirements of this UFC 3-560-1.

Inspections of tools and equipment that are used by an individual worker may be made by the authorized individual-in-charge at any time. Use of employee owned test equipment is prohibited.

Rubber or other approved protective equipment must be used on all conductors or energized parts, which could be contacted by a worker climbing to or reaching from a work position. Rubber or other approved protective equipment must be rated for the voltage encountered.

Establish safe clearance and lockout/tagout procedures at each facility.

Verify that existing permanent electrical system grounds are adequate for personnel protective grounding, and provide additional temporary grounding as necessary.

Be sure to check single line diagrams and verify that all inputs and interconnections to any electric power source are locked and tagged open. Verify single line diagram connections with the actual line connections of the applicable equipment.

Consult the manufacturer's instruction manual if available for the apparatus before starting work.

Before starting work on de-energized circuits or equipment, verify zero voltage on the circuit with a confirmed properly operating voltmeter.

When working on or near energized circuits, workers must stand on a dry surface.

Use properly grounded portable electric tools, particularly in damp locations or near grounded equipment or piping. Do not open a ground connection to a water pipe or ground rod until the ground wire has been disconnected at the equipment.

**MATERIAL SAFETY DATA SHEETS (MSDS)**
HAZARDOUS NON-ROUTINE TASKS

Prior to introducing a new chemical hazard into any section of this company, each employee in that section will be given information and training as outlined above for the new chemical hazard.

Periodically, employees are required to perform hazardous non-routine tasks. Some examples of non-routine tasks are: confined space entry, operation of compressed air equipment, working next to the edge of the roof.

Prior to starting work on such projects, each affected employee will be given information by the manager about the hazardous chemicals he or she may encounter during such activity. This information will include specific chemical hazards, and protective and safety measures the employee can use.

## MULTI-EMPLOYER WORKPLACES

It is the responsibility of the manager to provide other employers, with employees at the work site, copies of MSDSs (or make them available at a central location) for any hazardous chemicals that the employee may be exposed to. The manager will also inform other employers of any precautionary measures that need to be taken to protect employees during normal operating conditions or in foreseeable emergencies, and provide an explanation of the labeling system that is used at the work site.

# REPORT DOCUMENTATION PAGE

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Demonstration of a Mixed Oxide Process for Control of Corrosion and Microbiological Growth in Cooling Towers

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**14. ABSTRACT**
The deterioration of heating and cooling systems is considered the top facility corrosion problem by Army facility managers, because heating and cooling services are mission-critical. Cooling towers are susceptible to fouling due to the buildup of algae and other microbiological growth, which can cause corrosion, reduce energy efficiency, and spread disease. A new process has been developed to replace chlorination in cooling water systems by generating an effective biocide on-site using ordinary table salt (sodium chloride) and water in an electrolytic cell. Three cooling towers were treated with this technology at Corpus Christi Army Depot, TX, and a fourth tower was monitored without treatment as a control. The earliest data collected indicate that the pH and conductivity of the cooling tower water did not change significantly after the mixed oxidant generation system was implemented, so no water chemistry adjustments are necessary. Also, the level of microbial activity in the water remains at low pretreatment levels. The data from an independent analysis by the Illinois State Water Survey are not yet available. Data collection and analysis, both at the site and from samples sent to the water survey, will continue through December 2008.

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